EIGHTH ANNUAL REPORT

of the

U. S. Regional Pasture Research Laboratory

State College, Pa.

1944

1944

Eighth Annual Report

U. S. Regional Pasture Research Laboratory

State College, Pennsylvania

Division of Forage Crops and Diseases

Bureau of Plant Industry, Soils, and Agricultural Engineering

and

The Agricultural Experiment Stations

of the

Northeastern States

Cooperating

Forty-five copies of this report were made and distributed as follows:

Seven copies to the Division of Forage Crops and Diseases; one copy to each of the twelve Directors of the cooperating State Agricultural Experiment Stations in the Northeastern United States; one copy to the President of The Pennsylvania State College; one copy to the Conservator of the Northeastern Region of the Soil Conservation Service, Upper Darby, Pennsylvania; one copy to the Director of each of the following State Agricultural Experiment Stations--Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin; one copy to the Dominion Agrostologist, Ottawa, Canada; one copy to the Main Library of the Department of Agriculture, Ottawa, Canada; one copy to the Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; one copy to the Director of the Swedish Seed Growers Association, Svalof, Sweden; one copy to the Director of the Waite Agricultural Research Institute, Adelaide, Australia; one copy to the Librarian, Division of Plant Industry, Council for Scientific and Industrial Research, Canberra City, A.C.T., Australia; and the remaining four copies to the U. S. Regional Pasture Research Laboratory.

B.

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This annual report of activity at the Pasture Laboratory, as well as of that at the state stations with which the Laboratory cooperates, is a progress report and as such may contain statements which may or may not be verified by subsequent experiments. The fact that any statement has been made herein does not necessarily constitute publication. For this reason citation to particular statements in the Report should not be published unless permission has been previously granted by the Laboratory or the state station concerned.

TABLE OF CONTENTS

REPORT

of the

UNITED STATES REGIONAL PASTURE RESEARCH LABORATORY

for the Calendar Year 1944

INTRODUCTION

The end of the year 1944 finds us still in the midst of war and with prospects for an early termination uncertain. There has been no basic change in the forage crop problems of the Northeastern United States particularly those problems most closely identified with an expansion in the production of livestock products. In lieu of the ample stocks of concentrates available from the Middle West during peace times, it continues to be particularly important to grow and feed high quality roughages rich in protein, whether the roughages be in the form of pasturage, hay or silage. Seed stocks of some forage crops appear to be ample to meet the demand but seed stocks of others are inadequate. The research program of the Laboratory continues to emphasize those lines of activity which appear most promising in solving important forage crop problems accentuated by the war.

During the year, there was developed with the Pennsylvania Agricultural Experiment Station a master project involving various phases of evaluating pasture species both when grown alone and in mixtures. This project includes studies on grazing management, on response to various fertilizers and lime, on renovation practices, and on evaluating newly developed strains of the pasture species. The proposed work together with that already under way on breeding Kentucky bluegrass and on determining nutritional values of certain pasture species constitutes a good example of what may be done in developing a cooperative pasture research program at any station in the region. These jointly planned studies are the culmination of a series of conferences between staff members of the Pennsylvania Agricultural Experiment Station and of the Laboratory. The active encouragement of the Director of the Pennsylvania Experiment Station has been an important factor contributing to success in setting up such a plan. Although an outline of the work has been jointly developed the two agencies will continue formal cooperation only on those subprojects where personnel and facilities make it seem desirable to do so. The respective responsibilities of the project leaders in carrying on the various activities have been clearly defined and it is expected that they will keep one another informed on progress made by conferences from time to time. If in the progress of the work of either organization as set forth in the master project it ever becomes desirable to make major changes, such changes will be mutually planned.

Under the leadership of the Division of Forage Crops and Diseases there was organized last September a cooperative plan to develop alfalfa breeding in the Eastern States. At the present time the states primarily interested are New Jersey, New York, North Carolina, Ohio, and Pennsylvania. It is expected that the Laboratory will work closely with those states that lie within the Northeastern Region. An alfalfa nursery has already been established at State College, Pennsylvania.

The pasture collaborators did not meet in 1944 but a regional conference sponsored by them was held in New York City February 2 and 3 on forage crop seed supplies. Representatives of experiment station and extension staffs of nine states together with representatives of various Federal agencies and of three farmer cooperatives attended the meeting.

CHANGES IN PERSONNEL

Doctor S. S. Atwood, formerly Associate Agronomist in charge of breeding pasture legumes at the Laboratory, resigned May 1, 1944, to accept a position on the staff of Cornell University. Doctor W. M. Myers, formerly in charge of grass breeding, now has been placed in charge of both grass and legume breeding and two assistants have been added to the staff to help him in this work. The assistants are Mr. K. G. Brown and Mr. E. J. Dollinger. The former completed his undergraduate work at The Pennsylvania State College and the latter at Ohio State University. Mr. Brown has also completed his course work for the doctorate at Iowa State College. Routine work in the field, laboratory, and greenhouse has been curtailed somewhat owing to a shortage of help.

REGIONAL SEED CONFERENCE

The conference on forage crop seed supplies sponsored by the collaborators of the Pasture Laboratory was held for the purpose of discussing various phases of the critical seed situation and to develop suggestions and plans as to how best to meet it. A 16-page mimeographed report was prepared and mailed to each attendant at the meeting as well as to others who might be interested.

After discussing the then current seed situation and the factors that brought about the shortages, the conference developed specific suggestions as to what might be done to conserve existing seed stocks by reducing rates of seeding, by taking the necessary steps to insure crop establishment, and by maintaining existing stands as long as possible. The possibilities of local seed production from existing stands were discussed in some detail, and, although certain difficulties were recognized, it was concluded that every encouragement should be given to the production of more locally

grown seed. Possibilities along this line with Ladino clover, red clover, and orchard grass were emphasized. Brief consideration was given to the establishments of new plantings in 1944 for seed production. The conference went on record as favoring the encouragement of more forage seed production at the national level particularly in the major seed producing areas.

The members of the conference spent considerable time in discussing effective ways and means of bringing to the attention of farmers in the Northeast the critical situations with respect to some forage seeds and steps that may be taken to help solve the problems.

Information regarding various strains of forage crops of interest in the Northeast was assembled and included in the mimeographed report.

COOPERATIVE RESEARCH BETWEEN STATE STATIONS AND THE LABORATORY

In order to coordinate various phases of the forage crops research program at the Pennsylvania Agricultural Experiment Station and the Pasture Laboratory, a comprehensive project was developed during the past year that involves cooperative investigations among several departments of the Pennsylvania Agricultural Experiment Station and the Laboratory. Because of the varied nature of the research involved, the project was divided into several subprojects. The titles of these subprojects indicate the scope of the investigations and are as follows:

Subproject A. Evaluation of grasses and legumes for hay, grass silage, and pasture for dairy cattle (evaluation of species combinations and grazing management practices with dairy cattle). See page 16 of this report.

Subproject B. Preliminary trials of grasses and legumes for hay, grass silage, and pasture for dairy cattle. See page 93 of this report.

Subproject C. Evaluation of grasses and legumes for use as poultry pasture. See page 17 of this report.

Subproject D. Renovation of unproductive areas for pasture, hay, and silage. See pages 21 and 22 of this report.

Subproject E. The adaptation of species of grasses and legumes to the varying soil and climatic conditions in Pennsylvania. See page 95 of this report.

Subproject F. The importance of soil amendments in the establishment, maintenance, and production of grasses and legumes. See page 94 of this report.

The Pasture Laboratory has assumed primary responsbility for the agronomic phases of subproject A and of those parts of subproject D that are conducted at State College, Pennsylvania, and will assist with the agronomic phases of subproject C. Reports of these three subprojects are included in the Annual Report as cooperative projects; the remainder are included as state reports from the Pennsylvania Agricultural Experiment Station.

AGROSTIS TENUIS BREEDING (WITH RHODE ISLAND)

Title: Breeding Rhode Island Colonial Bentgrass for Pasture Types.

Leaders: For the Rhode Island Agricultural Experiment Station - Irene H. Stuckey.
For the Pasture Research Laboratory - W. M. Myers.

The clonal plots which were planted in the fall of 1943 grew satisfactorily during the spring and early summer. There were noticeable differences in earliness of growth among the different selections and in the amount of growth as measured by yield of clippings. But by the middle of July the effects of drought masked any differences in rate of recovery and no further measurements could be made. The broad leaved forms are apparently less drought resistant than the narrow leaved types.

Selection for desirable pasture types was continued. Diseases were not nearly so severe as during the previous summer but wide differences in resistance were observed. In connection with this work, chromosome counting was resumed after a lapse of two years. The results obtained comfirmed the initial findings. The chromosome numbers are very variable, varying from 30 to 40. There seems to be no correlation between chromosome number and plant morphology. Plants which taxonomically appear to be definite species types show evidence of hybridity in the variable chromosome numbers. More evidence is needed before even tentative conclusions can be reached concerning the Agrostis complex.

DACTYLIS GLOMERATA, LOLIUM SPP., AND FESTUCA SPP. BREEDING (WITH MARYLAND AND DIVISION OF FORAGE CROPS AND DISEASES)

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass (Dactylis glomerata), Ryegrass (Lolium perenne and L. multiflorum), and Fescue (Festuca spp.) Strains Adapted Particularly for Pastures in Maryland.

Leaders: For the Maryland Agricultural Experiment Station - W. B. Kemp.
For the Division of Forage Crops and Diseases - M. A. Hein.
For the Pasture Research Laboratory - W. M. Myers.

ORCHARD GRASS

Collection of Material. A nursery of approximately 4,000 spaced plants was established at State College, Pennsylvania, and one of about 2,000 plants was established at Beltsville, Maryland, to

provide a source of material for new selections. The plants were from seed of existing strains, strains developed in this breeding program, and a few collections from natural stands.

Selections and Evaluation of Plants. Records were taken on the clones in the 1942 polycross blocks (1942 Annual Report, page 7) at Beltsville and State College. On the basis of these records almost half of the clones were discarded. Seed was harvested from the remaining 149 clones. Additional clones were discarded because of poor recovery following clipping after the seed harvest. The remainder will be seeded in replicated plots in association with Ladino clover in the spring of 1945.

Strain Trials. Observational records were taken on the plots of strains and single crosses (1942 Annual Report, page 7). Since stands of several strains and single crosses were poor as a result of the severe winter injury in 1942-43, yield records were not taken. Significant differences among crosses were obtained in estimated earliness of spring growth, yield, recovery following clipping, compatibility with Ladino clover, and resistance during midsummer to leaf spot. The two strains produced from Maryland material continued to give superior performance in plot tests at Beltsville.

New Strains. From one-half to two pounds of seed were obtained from each of five isolation plots (double crosses) at State College, Pennsylvania, and from each of the five isolation plots at Beltsville, Maryland (1943 Annual Report, page 5). The five strains from Beltsville were included in a strain trial planted in a dairy pasture at the Beltsville Research Center. All of the 10 strains will be used for seeding strain tests at State College in the spring of 1945.

Seed increase plots were established at State College, Pennsylvania of the two strains designated Synthetic No. 1 and Synthetic No. 2 (1942 Annual Report, page 6).

MEDICAGO SATIVA BREEDING (WITH NEW YORK AND DIVISION OF FORAGE CROPS AND DISEASES)

Title: Breeding Varieties of Alfalfa for Pasture and Hay.

Leaders: For the New York (Cornell) Agricultural Experiment Station - S. S. Atwood.
For the Division of Forage Crops and Diseases - H. M. Tysdal.
For the Pasture Research Laboratory - W. M. Myers.

The importance of alfalfa as a hay plant in the eastern United States has been increasing for several years. Recently, there has been a growing appreciation of the potentialities of alfalfa as a pasture plant, particularly for use in renovation and for

intensively managed short ley plantings to be used for hay and pasture. Increased usage of alfalfa is limited, however, by the lack of bacterial wilt resistant varieties adapted to the soil and climatic conditions of the East and tolerant to the frequent defoliation encountered in use for pasture.

During the past year a beginning has been made in developing plans for an eastern alfalfa improvement program, designed to develop varieties of alfalfa resistant to common diseases, adapted to eastern conditions, and, if possible, tolerant of grazing during at least part of the growing season. As one phase of this program, a cooperative alfalfa breeding project was initiated between the New York (Cornell) Agricultural Experiment Station, the Livision of Forage Crops and Diseases, and the U. S. Regional Pasture Research Laboratory. Alfalfa breeding investigations will be conducted at the Laboratory and at Cornell, the two breeding programs to be coordinated by frequent conferences of the project leaders, and by exchange of materials. The Division of Forage Crops and Diseases will function primarily by helping to coordinate this breeding program with similar western programs, and will arrange, when desirable, for seed production of selections, strains, hybrids or other material at a western station.

Small space-planted nurseries, of a few hundred plants, were established in the spring of 1944 at State College, Pennsylvania, and Ithaca, New York. In the fall approximately 6,000 seedlings (from Buffalo, Ranger, Cossack, 39-1227, 39-1272, 39-1268, 39-1269, and 39-1019) were inoculated with wilt and planted in the greenhouse at State College, Pennsylvania. The survivors will be planted in the nursery in the spring of 1945.

POA PRATENSIS BREEDING (WITH PENNSYLVANIA)

Title: Breeding Kentucky Bluegrass for Improved Pasture Types

Leaders: For the Pennsylvania Agricultural Experiment Station - J. K. Thornton and S. I. Bechdel.
For the Pasture Research Laboratory - W. M. Myers.

Seed Increase. Seed was harvested again from the 4 improved strains of Kentucky bluegrass reported in the 1943 Annual Report, page 16. Seed increase plots of one-half acre each were planted with seed of two of these strains. A small increase of seed is being made with a number of uniform selections to prevent the loss of valuable material.

Advanced Plot Trials. Replicated pasture plots were seeded with four improved strains and commercial seed of Kentucky bluegrass. These plots will be grazed by dairy cattle. Yield records and other data will be obtained in 1945.

POA PRATENSIS AND TRIFOLIUM REPENS BREEDING (WITH WEST VIRGINIA)

Title: Breeding and Improvement of Pasture Grasses and Legumes.

Leaders: For the West Virginia Agricultural Experiment Station - G. G. Pohlman (Temporary), J. G. Leach, and Conley Lowther.
For the Pasture Research Laboratory - W. M. Myers.

Observations on the bluegrass progeny test started in 1943 showed that the majority of the strains were not breeding true. Seed was selected from forty lines which had the least number of aberrant plants. (The seed was planted in triplicate plots, each plot consisting of three rows 9 feet long and one foot apart for further study on homogeneity, yield, and ability to form sod.) The strains selected represented a rather wide variety of types, some being low growing with relatively few seed heads whereas others were quite erect and had many seed heads.

The bluegrass seeded in plots, 3 by 12 feet, in 1942 to study association with white clover was discarded because of the large amount of red clover in the plot resulting from a previous crop which had gone to seed.

Work has been handicapped by a shortage of help and also by the loss of Doctor Wellhausen. Pathological work has dealt chiefly with a study of inoculation methods for testing bluegrass for stripe-smut resistance. Numerous methods of inoculating bluegrass with stripe smut (Ustilago striaeformis) have been tested. The conventional methods of seed inoculation, with or without vacuum treatment and using various types of inoculum, have resulted in such low percentages of infection, and the incubation periods have been so long, that they are considered impractical for eliminating susceptible strains. Inoculation of plants near the growing point, using a hypodermic syringe and fresh spore suspensions, has given better results. With this method the incubation period has been as short as 13 days as compared with 6 weeks for seed inoculation. An important feature of the hypodermic-syringe method is that, without resorting to seed production, clonal selections can be re-inoculated over and over with adequate replications until resistance or susceptibility is determined definitely.

TRIFOLIUM REPENS BREEDING (WITH NEW JERSEY)

Title: Breeding White Clover for Pastures.

Leaders: For the New Jersey Agricultural Experiment Station - G. H. Ahlgren.
For the Pasture Research Laboratory - W. M. Myers.

Progeny Test of Diallel Crossing System. During 1944 the group of 38 crosses planted in the spring of 1942 was further evaluated and decisions as to the combining ability of the parent plants entering into these crosses were made.

Since 1940 a total of 312 white clover crosses or their reciprocals have been tested in seven plant rows replicated three times in so far as was possible. Crosses possessing superior combining ability as judged on the basis of vigor, variability, absence of disease, persistency, and other characters have been isolated. Each plant tested for combining ability has been evaluated also on the number of times it proved superior in combinations with other parent plants. A summary of these data is given in Table 1.

Evaluation of the parent plants has been placed on a percentage basis. For the purpose of selecting those of superior combining ability it might be suggested that all plants entering into superior crosses 30 per cent of the time or more be judged good enough for continued use in the breeding program. Rather than do this it is proposed that personal judgment be exercised based upon observations of the performance of these plants over the 5-year period that the combinations have been used. Accordingly, only those starred are considered superior and while some of the others were good as shown by their percentage rating they are not placed in the elite class.

Table 1. Evaluation of parent plants used in the diallel crossing system.

New Jersey number	Pasture Laboratory number	Number of crosses or reciprocals in which parents appear	Number of superior crosses or reciprocals in which parents appear	Per cent occurrence in superior combinations
3-10	6-1	17	3	18
3-12	6-2	19	5	26
3-20	6-3	15	9	60*
3-23	6-4	16	5	31
19-2	6-5	17	7	41*
19-7	6-6	19	6	31*
27-5	6-7	17	3	18
36-21	6-8	11	4	36
36-23	6-9	10	8	80*
36-38	6-10	18	10	56*
36-44	6-11	10	1	10
36-44	6-12	12	1	9
Dixie 13	6-13	18	4	22
Mo. 5	6-14	16	5	31
Mo. 6	6-15	20	9	45*
Mo. 33	6-16	19	10	53*
Ladino 6	6-17	16	5	31
Ladino 14	6-18	12	2	17
Ladino 18	6-19	16	4	25
Ladino 42	6-20	14	1	7

* Judged superior on basis of outstanding combining ability in greatest number of crosses.

Continuous Selection from Six Isolated Open-pollinated Strains. About 200 plants grown from seed harvested from six superior plants allowed to cross-pollinate freely were set into the field from the greenhouse early last spring. They were transplanted to an isolated field where no wild white clover existed in so far as could be determined. The entire area, most of which is used as a foundation hybrid corn field, is surrounded by woods and, therefore, is well protected.

The past season was not particularly favorable to the growth and development of these plants since the weather was extremely hot and dry. In addition rabbit injury was pronounced on several occasions during the season. Nevertheless for the most part the plants are well established and it may be possible to select superior plants and secure seed from them in 1945.

The control of rabbits in some manner so that they do not graze the clover in these isolated areas is a major problem in securing clover seed. The use of fine netted wire placed around the plot has been the most effective method used to date.

TRIFOLIUM REPENS, TRIFOLIUM PRATENSE AND PHLEUM PRATENSE BREEDING (WITH NEW HAMPSHIRE)

Title: The Improvement of Ladino Clover, Red Clover and Timothy by Selection and Breeding.

Leaders: For the New Hampshire Agricultural Experiment Station - Ford S. Prince, L. J. Higgins, and Paul T. Blood.
For the Pasture Research Laboratory - W. M. Myers.

Ladino Clover. Twenty-four plants were selected in the autumn of 1943. These represented original Ladino parents and superior individual plants of the F_1, F_2 and F_3 generations of stock obtained by intercrossing large wild white clovers and Ladino in the F_1 generation and backcrossing to Ladino in the F_2 and F_3 generations.

These plants were propagated clonally in the greenhouse during the winter. Cuttings of plants 1 to 9, inclusive, were set in triplicate for caging. As the season developed, bees were introduced into the cage and seed was secured from each plant. This seed now awaits propagation and the progeny thereof will be subjected to further testing.

All 24 plants were used for testing in small plots. Clonal material from each was set in triplicate plots, 3 by 6 feet, 14 cuttings per plot, on land that had been currently seeded to orchard grass. Notes are being taken on competition, height, ability to recover after clipping and like factors.

A few of the 15 plants in this group not caged in 1944 appear to have more promise than many of the nine that were caged, hence the cage will again be used in 1945 with a new grouping for seed production of the most desirable material.

Similar plant material from other stations is being subjected to field tests like those described above.

Red Clover. Twenty-five potted seedlings are in the greenhouse for the usual winter crossing by hand. These seedlings represent the more persistent of the 12 families selected for their ability to live more than two seasons and F_1, F_2 and F_3 generations obtained by intercrossing.

This year, there were none of the old plants of the 12 original families alive in the field plots. Some of the original plants had produced seed four and five seasons. Seed multiplication has continued both in the field and plot areas. In spite of excess winterkilling of all plants there are a few plants that are three years old at present.

From now on an attempt will be made to discard plants that show disease and general lack of vigor, and to test bulk seed of this new strain in comparison with other standard and improved strains. After this selection and testing, an effort will be made to multiply the strain rapidly if it shows sufficient promise.

Timothy. Due to unfavorable soil conditions on the area in which seed from clonally propagated plants were seeded it was impossible to check the behavior of individuals in the two strains of timothy under observation. Seed from each clone will again be put into the ground for testing in the spring of 1945.

Plantings of composites of each strain have been made for seed increase. About 50 pounds of the late hay and five pounds of seed of the pasture strain were secured in 1944. This seed will be tested, probably in some trials on farms in 1945.

MICRO-CLIMATE STUDIES (WITH VERMONT)

Title: Micro-climate and the Growth of Several Pasture Species.

Leaders: For the Vermont Agricultural Experiment Station - J. W. Marvin.
For the Pasture Research Laboratory - V. G. Sprague.

Micro-climate Data. Since January 1943 continuous data have been taken on several environmental factors including air temperature at six feet and at three inches, soil temperature at soil surface and three inches below the surface, relative humidity, precipitation, light intensity and soil moisture at three, nine and eighteen inches.

Three inches of soil have a considerable insulating value as may be seen from the range in temperatures recorded in the different locations for a 24-hour period during the summer: at three inches below soil surface, a range of 5° F.; at soil surface, a range of 40°; and at three inches above soil surface, a range of 60° or more. Thus, it is apparent that the roots of grasses are subject to a much more even temperature than the plant parts which are on the surface of the soil or exposed to the air.

Marked differences in light intensity have been observed, not only from day to day but seasonal--for instance, there are nearly five times as many foot-candle hours for a week in the early summer as for a week during the short days of winter. It is intended to correlate these data with the growth and survival of some of the common grasses and legumes.

Species Tests. In June 1943, 100 small plots were established using seed furnished by the Pasture Research Laboratory. These plots consisted of 25 combinations of grasses and clovers in four replications. The grasses were orchard grass, reed canary grass, bromegrass, and timothy. The legumes were birdsfoot trefoil, Ladino clover, sweet clover, red clover, and alfalfa. The plots were established on a clay loam and were fertilized with an 8-16-16 mixture at the rate of 400 pounds per acre.

The plots were cut first in August 1943. The sweet clover-grass mixtures gave the best yields, although combinations with Ladino clover were nearly as good.

In 1944 the plots were cut three times and the dry-weight yields are given in Table 2. Of the legumes, alfalfa and red clover gave the highest yields. Very few sweet clover plants survived the first winter. This may have been due to the fact that when the plots were cut in 1943, all the plots were cut at the same height and the sweet clover plants may have been cut too close to the soil surface. The dry weights for sweet clover-grass combinations in the table include a rather high per cent of weeds. Birdsfoot trefoil did poorly as compared with Ladino clover, alfalfa and red clover, although a good stand of birdsfoot trefoil developed on most of the plots. As in the case of sweet clover, the yields given for birdsfoot trefoil in the table contain a high per cent of weeds.

Survival data and yields will be taken again in the summer of 1945, when greater differences may appear between the grasses as the legumes become a less important part of the population.

Table 2. Total yields in pounds per acre of the several grass-legume mixtures in 1944.

	Reed canary grass	Orchard grass	No grass	Brome-grass	Timothy	Average
Alfalfa	4696	4872	3869	4313	4254	4401
Red clover	3456	4211	4073	3100	2940	3556
Ladino clover	3376	2679	2548	2954	2599	2831
Birdsfoot trefoil	2315	2055	2337	2207	2279	2239
Sweet clover	1800	1459	2193	2404	1706	1912
Average	3129	3055	3004	2996	2756	2988

NUTRITION STUDIES (WITH PENNSYLVANIA)

Title: Measurement of the Nutritive Value of Pastures and of Pasture Plants.

Leaders: For the Pennsylvania Agricultural Experiment Station - E. B. Forbes, C. F. Noll, F. L. Bentley, E. W. Callenbach, A A. Borland.
For the U. S. Regional Pasture Research Laboratory - J. T. Sullivan and V. G. Sprague.

It is intended in this project to measure the nutritive values of pastures and of pasture plants as affected by species and variety of forage, time of year, climatic factors, management practices, soils, and fertilization.

Pasture values of the herbage, expressing yields as total digestible nutrients, will be determined by feeding the herbage to sheep under controlled conditions of experimentation. Other measurements of nutritive value, and supplementary chemical studies of the forage plants, will be made as occasion develops.

The Departments of Agronomy, Animal Husbandry, Poultry Husbandry and Dairy Husbandry of the Experiment Station, and the Pasture Research Laboratory will be primarily responsible for the producing, harvesting, and drying the forage crops in which they are particularly interested.

The Institute of Animal Nutrition is to be primarily responsible for determining nutritive values and for making chemical analyses as adjuncts to such trials.

The Pasture Research Laboratory will obtain samples of all pasture forage used in determinations of nutritive value for the purpose of making chemical determinations of any compounds in which it may

have a special interest. These supplementary chemical studies will be made on plant substances as mutually agreed upon from time to time as the investigations progress.

Preliminary to the measurement of pasture values in terms of digestible nutrients of the forage for sheep, a digestion experiment was conducted by the Institute of Animal Nutrition with 22 sheep, all on the same ration, to determine the number of individuals needed for each experimental treatment.

In consideration of the variability of the digestion coefficients observed in this test, after the sheep had been subjected to anthelmintic treatment, it was concluded that in so far as animal variability is concerned five individuals per experiment is a sufficient number to serve the purposes of this investigation. No test was made of field variability.

The following species were seeded August 10, 1944, in one-sixth acre plots: Kentucky bluegrass, timothy, orchard grass, bromegrass, alfalfa, and Ladino clover. Each species was replicated and randomized. The area used for this experiment was plowed in August 1943 and fallow cultivated during the summer of 1944 to control weeds. The lime requirement was satisfied and a liberal amount of a complete fertilizer was applied over the entire area.

OVER-LIMING INJURY (WITH CONNECTICUT)

Title: A study of the Causes of Over-liming Injury to Pasture Species.

Leaders: For the Connecticut (Storrs) Agricultural Experiment Station - B. A. Brown.
For the Pasture Research Laboratory - R. R. Robinson and V. G. Sprague.

Several groups of pots, established in 1941 or 1942, and which had grown alfalfa during the intervening summers, were uniformly fertilized with PK and reseeded to alfalfa in the spring of 1944. Besides taking occasional notes on growth and any deficiency symptoms, yields of dry matter were determined for two cuttings made on August 11 and September 26.

Results. Where no carrier of boron had been applied in 1941 or 1942, boron deficiency was quite prevalent on both moderately /2 tons $Ca(OH_2)$/ and heavily /4 tons $Ca(OH_2)$/ limed Charlton fine sandy loam soil, but not on Merrimac fine sandy loam. In general, borax at 20 pounds in 1941 or 1942, increased the yields of alfalfa on both soils in 1944. There were no indications of over-liming injury and in most cases, the yields were larger on the heavily limed than on the moderately limed soils. This corroborates earlier data showing the over-liming injury to soybeans decreased or disappeared with the second or third successive crops.

PASTURE MANAGEMENT EXPERIMENTS
(WITH MAINE)

Title: Management Practices as They Affect the Productivity and Persistence of Ladino Clover-Grass Associations.

Leaders: For the Maine Agricultural Experiment Station - C. H. Moran, J. A. Chucka, G. M. Cairns.
For the Pasture Research Laboratory - V. G. Sprague.

Work on this project was begun in the fall of 1944 with the preparation of land for a series of 18 paddocks on the University Farm. The soil type selected was a marine clay of the Suffield-Hartland series and is similar to a large area in the central part of the State which now consists mainly of unimproved hay and pasture fields.

The object of the study is to investigate the effects of several management systems on the seasonal productivity of the Ladino clover-grass associations and to determine the effects of the various management practices on the persistence and maintenance of the legume.

Duplicate areas will be seeded to associations of

1. Bromegrass-Ladino clover.
2. Timothy-Ladino clover.
3. Orchard grass-Ladino clover.

On each association three management systems will be used.

1. Graze all season when 8" to 10" high back to 2" to 3".

2. Remove the first crop for hay or silage when most of the grass heads have emerged from the boot and graze the aftermath when 8" to 10" high back to 2" to 3".

3. Remove the first crop for hay or silage when the grass is at the full bloom stage and graze the aftermath when 8" to 10" high back to 2" to 3".

Complete grazing will be insured by the use of a herd of 30 animals.

PASTURE MANAGEMENT EXPERIMENTS
(WITH PENNSYLVANIA)

Title: Evaluation of Grasses and Legumes for Hay, Grass Silage, and Pasture for Dairy Cattle.

Leaders: For the Pennsylvania Agricultural Experiment Station - S. I. Bechdel, P. S. Williams, and J. K. Thornton.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

Objectives.

1. To evaluate different systems of grazing management with dairy cattle on grass-legume mixtures with regard to total and seasonal productivity and to maintenance of a satisfactory grass-legume association.

2. To evaluate various grass-legume associations, under grazing by dairy animals, in terms of productivity (as measured in crop and animal units), persistence, palatability, and other factors of importance.

Systems of Grazing Management on Orchard Grass-Ladino Clover.
During 1944 a 10-acre field was limed and fertilized and seeded to a mixture of orchard grass and Ladino clover. The area was divided into 15 paddocks on which each of the five following management systems will be studied in triplicate plots.

1. Early spring grazing followed by rotational grazing.

2. Deferred spring grazing followed by rotational grazing.

3. Early spring grazing, then recovery for grass silage or hay followed by rotational grazing.

4. No spring grazing but cut for grass silage followed by rotational grazing.

5. Continuous grazing; the number of animals to be adjusted as required by the growth of herbage.

Grazing will be started in the spring of 1945. Immediately prior to each grazing period, strips will be cut for botanical analysis and yield determinations. Comparable strips will be cut for yield when grazing ceases in an effort to estimate consumption. Such information as milk yield, rise or fall in milk flow when shifted from one plot to another, live weight gains of young stock as well as observations on the health and activity of the cattle will be taken as facilities permit.

To provide a comparison with a Kentucky bluegrass pasture, three areas, one on each end and one above the center of the 10-acre field, will be fenced in existing good permanent pastures. These areas will be fertilized adequately and managed as well as present information permits. Yield data, grazing records, etc. will be taken in the same manner as from the orchard grass-Ladino clover area.

Evaluation of Several Grass-Legume Mixtures under Rotational Grazing with Dairy Cows. On triplicate plots about one-third acre in size the following grass-legume mixtures were seeded in May 1944:

1. Timothy
   Red clover
   Ladino clover

2. Orchard grass
   Ladino clover

3. Orchard grass
   Alfalfa

4. Bromegrass
   Ladino clover

5. Bromegrass
   Alfalfa

The herbage from the first crop of these mixtures will be ensiled for feeding tests during the winter. The aftermath will be grazed rotationally and agronomic and animal data obtained similar to that taken in the trials with orchard grass-Ladino clover above.

PASTURE MANAGEMENT EXPERIMENTS (WITH PENNSYLVANIA)

Title: Evaluation of Grasses and Legumes for Use as Poultry Pasture.

Leaders: For the Pennsylvania Agricultural Experiment Station - J. K. Thornton, P. H. Margolf, E. W. Callenbach, H. W. Higbee.
For the Pasture Research Laboratory - V. G. Sprague.

The objectives of this work may be summarized as follows:

1. To evaluate the effect of several systems of pasture management in the production of nutritious herbage and in the maintenance of adequate ground cover.

2. To evaluate the productivity (as measured in both agronomic and animal units), the persistence and the relative palatability of several species of grasses and legumes when grown in various associations.

Grazing Management of Orchard Grass-Ladino Clover as Pasture for Turkeys. Eight 1/2-acre enclosures were seeded with orchard grass and Ladino clover in May 1944. Two systems of rotational grazing (four areas for each system) differing only in the intensity of grazing by the turkeys will be used. Samples of herbage for yield and botanical composition will be obtained just before the turkeys are turned into any area. Records will be maintained on consumption of grain and mash and weights of the birds will be determined at various times throughout the season. Close observations will be made on the response of the grass and legume species to the droppings of the turkeys and particularly the effects of nitrogen in stimulating the grass.

Response of Various Grass and Legume Species to Grazing by Turkeys. The following species of grass were seeded with Ladino clover in May 1944 on replicated plots for grazing by turkeys: reed canary grass, tall oat grass, bromegrass, tall fescue and Kentucky bluegrass. These plots, 33 by 50 feet, will be grazed rotationally. Samples for yield and botanical estimates will be taken before the turkeys are admitted. Estimates of persistence and ground cover will be made each spring and fall and observations on any preference by the turkeys for the several species will be noted at several times during the grazing season.

PASTURE RENOVATION EXPERIMENTS (WITH CONNECTICUT)

Title: Grassland Renovation Trials in Connecticut.

Leaders: For the Connecticut (Storrs) Agricultural Experiment Station - B. A. Brown and R. I. Munsell.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

1. The eighty plots in this experiment involving five treatments and four seed mixtures were seeded on Field M in the spring of 1943 and were mowed twice (June 9 and August 15) for dry matter yields in 1944.

Results. Because of much better establishment of legumes on the "disked" area, yields were again much higher (at least 50 per cent) on that section than on the manure, or weed killer (Atlacide or sulphuric acid) treated sections.

Among the four seedings, the mixture of red and Ladino clovers was consistently superior to Ladino alone or Ladino and orchard grass. Birdsfoot trefoil produced about the same as the Ladino seedlings.

2. Tests of "weed-killers" to reduce competition of perennial grasses to seeded legumes in renovation of pastures.

Over a period of several years, such promising results had been obtained in establishing clovers on untilled grassland previously treated with Atlacide to kill or retard the grasses that it was deemed advisable to test the efficiency of other materials with the object of finding a less expensive, more effective, and a more easily applied chemical. Therefore, from April to October 1944, 330 plots, 10 by 10 feet, on long established grassland were treated with Atlacide, ammonium thiocyanate, activated arsenical or borax, each material being applied at three different rates, three different dates, and followed by seeding Ladino clover at three dates after treatment. In some cases, the chemicals were applied dry and in solution.

Results. Ammonium thiocyanate, added dry in April at 100 or more pounds per acre, was very effective in killing perennial grasses. During the season, however, some annual weeds appeared on the 100-pound plots, few on the 200-pound plots, but scarcely any on the 400-pound plots. Ladino seeded in April at the same time as the thiocyanate did not become established at all, while June seedings did result in considerable clover by fall in spite of the extremely dry weather from late June to mid-September.

The ammonium thiocyanate at 100 pounds was much more effective in killing existing vegetation than Atlacide at 200 pounds, borax at 200 pounds, or activated arsenical at eight gallons per acre.

PASTURE RENOVATION EXPERIMENTS (WITH MASSACHUSETTS)

Title: Grassland Renovation Experiments in Massachusetts.

Leaders: For the Massachusetts Agricultural Experiment Station - W. G. Colby.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

During 1944 five additional cooperative renovation experiments similar to those described last year were started with farmers in central Massachusetts. These experiments were laid out on fields which differed widely in topography, character of the native vegetation, degree and nature of stoniness and soil drainage relationships. This was done intentionally; for, as renovation work progressed, it has become increasingly obvious that different conditions require widely varying methods of procedure to secure the most effective results.

Without going into detail the following comments and observations appear to be significant and worthy of recording.

Degree of Stoniness. It is doubtful if attempts should be made to renovate stony land until most of the surface stones six inches or larger in diameter have been removed. If many surface stones of this size or larger are present, a bog harrow, for example, tends to bounce from rock to rock, and in so doing, becomes much less effective as a tillage implement and makes repeated working of the land necessary to secure a satisfactory seedbed. Excessive wear is caused not only on the harrow but on all machines which may be used subsequently. Once the surface stones have been removed, a bog harrow operates satisfactorily even though there is still an abundance of stones buried just below the surface of the ground.

Stone Removal. Some observations were made on the use of a large caterpillar tractor with regular bulldozer attachment for removing large stones and boulders. In the hands of an expert operator, this machine is a very efficient and practical means of removing large stones. Rocks weighing from one or two hundred pounds up to several tons can be removed in the course of a few minutes. If it is necessary to move stones more than a few rods, blade attachments which prevent stones from rolling off the ends are useful.

The removal of small stones is the most difficult problem to solve. There seems to be no other way except to pick them up by hand and this is a slow and arduous operation. It is particularly difficult where there is a firm sod. Most of the stones become imbedded in the sod and the use of a bar is necessary to pry each one loose. If after the large stones and boulders have been removed the land is worked once with a bog harrow, many of these imbedded stones will be dislodged and their removal thus facilitated.

Character of Native Vegetation. The effectiveness of different tillage implements is greatly influenced by the nature and amount of native vegetation.

1. Moss cinquefoil association: a bog harrow is particularly effective in destroying this type of cover. One thorough disking is usually sufficient

2. Grass sod: the destruction of a grass sod can be accomplished with a bog harrow, but several diskings are usually required. So far, disking at intervals of one to two weeks during midsummer has been the most effective means in destroying bluegrass and bentgrass sods. A closely grazed sod is easier to disk up than one where the grass is taller. If operations are begun in July, a satisfactory seedbed can usually be prepared by mid-August for a late summer seeding.

3. Herbaceous woody plants (ground pine, low-bush blueberry, hardhack, etc.): If the proportion of woody plants is large, the bog harrow is not entirely satisfactory, particularly if the soil is moist. Woody stems, including dead ones, are tough when wet and the harrow is unable to cut through the surface except after repeated diskings. In one experiment where this type of vegetation predominates, use of other implements including a brush-breaker plow is contemplated.

A bulldozer was found to be quite useful in leveling off uneven "hummocky" land by dragging the blade and operating the machine in reverse. This breaks the hummocks down and tends to tear them apart so that they will dry out. After they dry out, a bog harrow can be used effectively.

Thus far summer seedings have been much more successful than spring seedings. In many instances it is difficult to prepare a first-class seedbed anyway, and, if dry weather follows a spring seeding, as in 1944, poor grass stands result. If the seedbed were prepared in the late summer and fall so that seeding without a companion crop could be done in late winter or very early spring on honeycombed soil, it is probable that in most seasons a good stand of all seeded species would be obtained and sufficient growth made to practically eliminate serious competition from annual weeds and also provide considerable grazing or a hay crop during the summer of the seeding year. Dry weather frequently follows late summer seedings also, but the effects of late summer droughts are less damaging since the cooler fall weather which follows, along with the usual fall rains, almost always insures a satisfactory "catch".

PASTURE RENOVATION EXPERIMENTS (WITH PENNSYLVANIA, AT MONTROSE, AND DIVISION OF FORAGE CROPS AND DISEASES)

Title: Pasture Renovation Trials in Northeastern Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment Station - S. I. Bechdel and J. K. Thornton.
For the Division of Forage Crops and Diseases - S. R. Skaggs and M. A. Hein.
For the Pasture Research Laboratory - V. G. Sprague and and R. R. Robinson.

During the 1944 season, yields were obtained on June 24 and August 5 from the renovation plots seeded in the spring of 1943 (1943 Annual Report, pages 10 and 11) on a seedbed prepared with a field cultivator in the fall of 1942. The actual yields of these plots in their first harvest year were lower than might

normally have been expected due to the severe drought during July and August. There was a net deficiency of 4.47 inches of rainfall during these two months. As a result, only two cuttings were made from the legume-grass mixtures except for the alfalfa series which was cut but once.

A summary of the 1944 yield data, in which the legumes were evaluated by averaging the yields obtained from all the grass plots in which the legumes were included, showed that the several species of legumes had a very marked effect on total yield. The mixtures containing red and sweet clovers yielded 3,500 pounds per acre, red and Ladino clovers and alfalfa 3,250 pounds per acre, Ladino clover 2,475 pounds per acre, and birdsfoot trefoil 1,475 pounds per acre. The untreated sod yielded 853 pounds per acre whereas the sod which had received as a top-dressing the same amounts of lime and fertilizer as the renovated area but had not been tilled or seeded yielded 1,167 pounds per acre. Considering that due to dry weather the Ladino clover plots were cut only twice and the alfalfa cut once, it is probable that during a season of normal rainfall, both of these species would have more nearly approached the yield of red and sweet clovers.

The several species of grasses included in the mixtures resulted in very little if any increase in total yields of dry matter. This may have been due largely to the presence of volunteer grass that survived the tillage operation in the preparation of the seedbed.

PASTURE RENOVATION EXPERIMENTS (WITH PENNSYLVANIA, AT STATE COLLEGE)

Title: Pasture Renovation Trials in Central Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment Station - A. W. Clyde, J. K. Thornton, and C. O. Cromer.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

The first renovation experiment at State College (1943 Annual Report, pages 11 to 13) was continued during 1944. Due to an unusually long dry period during midsummer only two harvests were made. A summary of the yields from the various combinations of grasses and legumes indicates that alfalfa has been the most productive legume during the second year, 5,342 pounds per acre of oven-dry hay having been obtained as an average of all associations; Ladino clover was intermediate with an average yield of 3,454 pounds per acre; and birdsfoot trefoil was least with an average yield of 1,992 pounds per acre. This latter species, however, was cut only once due to a limited summer recovery this year and in order to favor its establishment during the first two years. During 1945 and subsequently it is the plan to harvest it at

least twice during the season. Up to the present time, no species of grass used has been exceptionally outstanding in increasing the yields of any mixture.

The untreated sod check plot and the sod top-dressed with lime and fertilizer at the same rate as the adjacent disked and seeded plots continued to be low yielding (less than one-half ton of dry matter per acre in both instances). Kentucky bluegrass and white clover are coming into the top-dressed plots, however, and a season of favorable rainfall during 1945 should increase the yield of these plots.

The differences in yield observed during the first year between plowing and disking as a method of seedbed preparation disappeared during the second year. The amount of grass in the hay was perhaps slightly higher on the plowed plots but all yielded approximately two tons per acre oven-dry hay. No effect of fertilizer placement, whether plowed under, disked in or drilled in, was apparent.

During the latter part of the summer of 1943, additional renovation trials were begun. The objectives of these trials were similar to those of the previous experiment, namely, to investigate the problems involved in establishment and maintenance of larger-growing grasses and legumes on unproductive pasture land. In all cases, liberal applications of lime, phosphate, and potash were made (200 pounds P_2O_5 and 150 pounds of K_2O per acre).

Methods of Seedbed Preparation. The implements used in studies of methods of seedbed preparation included the heavy disk (22-inch disks with 9-inch spacing), the field cultivator, a 24-inch sweep cultivator, a disk plow and a mold board plow. Close clipping of a sod in the fall and following spring to weaken it sufficiently to encourage the establishment of seeded species was tried.

The work required to prepare the seedbed by each of the above implements is summarized in Table 3.

Table 3. Estimated work performed in renovating an unproductive pasture sod with various tillage implements.

Implement Used	Estimated acres per day	Estimated drawbar horsepower-hours per acre
Mold board plow (shallow plowing)	6.3	12.6
Disk plow (shallow plowing, plus once over with cover crop disk)	4.5	17.7
24-inch sweep cultivator, plus once over with cover crop disk	6.75	13.4
Field cultivator twice, plus once over with cover crop disk	6.5	14.5
Cover crop disk three times	4.5	17.6

It will be noted that the work required to prepare the seedbed with a mold board plow is lower than with any of the other implements. This is in agreement with the results obtained the previous year (1943 Annual Report, page 12). The work performed in plowing was almost identical for both years, but the work performed in preparing the land with the disk and field cultivator is somewhat less in the second trial. This may in part be accounted for by the use of heavier implements the second year and by preparing the land soon after a rain which had softened the sod and facilitated tillage operations.

On each of duplicate plots prepared with the several implements and also on those prepared by clipping the herbage, triplicate subplots of the three following mixtures were seeded on March 31, 1944:

1.	2.	3.
Red clover	Red clover	Birdsfoot trefoil
Alfalfa	Alfalfa	Orchard grass
Ladino clover	Ladino clover	
Bromegrass	Orchard grass	

A good stand of all seeded species was obtained except on the plots prepared by clipping. Due to limited rainfall during July and August only one cutting (July 7) was taken from the plots. Botanical separations of samples of the herbage were made so that the total yield per plot as well as separate yields of grasses and legumes could be determined. The highest yields (about one ton per acre) were obtained on those plots prepared with both the field cultivator and the heavy disk. The plots prepared with a disk plow produced slightly less, and those plowed shallow with the mold-board plow yielded about three-fourth of a ton per acre. Plots prepared with the sweep cultivator yielded about 200 pounds per acre less than the plowed plots. The sweep cultivator did not subdue the sod as well as it was subdued by the other surface tillage implements. The lowest yield was obtained from the sod plots clipped to weaken the grass. On these plots there was almost no establishment of the seeded grasses, birdsfoot trefoil or alfalfa and but a limited establishment of red clover and Ladino clover.

The yields of the legumes plus orchard grass for all methods of seedbed preparation averaged 1,935 pounds per acre, those with bromegrass 1,761 pounds per acre, and the mixture of birdsfoot trefoil and orchard grass 1,121 pounds per acre, 69 per cent of this latter being grass whereas in the two former cases the contribution of grass toward the yield was 45 per cent and 32 per cent, respectively.

Grass and Legume Species Trials. Another part of the experimental area was adequately limed and fertilized as indicated above and thoroughly worked in August 1943 with a heavy disk to eliminate competition from existing vegetation. It was seeded March 31, 1944, when the ground was frozen.

Each of six grasses (orchard grass, bromegrass, timothy, tall oat grass, reed canary grass, and tall fescue) was seeded in all combinations with the following legume mixtures in quadruplicated plots 9 by 16 feet:

1.	2.	3.
Red clover Alfalfa Ladino clover	Alfalfa Ladino clover	Red clover Ladino clover

In addition birdsfoot trefoil and sweet clover and birdsfoot trefoil alone were seeded in all combinations with orchard grass, with tall oat grass, and with tall fescue.

These plots were cut on July 7 and yields and botanical separations of the grass and clovers were made from each plot. A summary in which the yields represent the acreage of all plots containing the indicated species is presented in Table 4. It is apparent that red clover, Ladino clover, and alfalfa are the more productive legumes during the seeding year and that timothy and tall oat grass become established sooner and are more productive than bromegrass and tall fescue during the year of seeding. It is interesting to note that the average yield of all grasses is approximately the same irrespective of the legume in the association but that the average yield of all legumes is reduced by those grasses which are higher yielding.

Table 4. Yields of the several grass-legume mixtures on the renovation plots at State College, Pennsylvania, from one cutting on July 7, 1944, following seeding on March 31 the same year.

Species	Per cent grass	Av. yield dry matter per plot		
		Total pounds per acre	Legumes pounds per acre	Grasses pounds per acre
	Legumes			
Red clover, alfalfa, Ladino clover	45	1942	1058	884
Red clover, Ladino clover	45	1905	1048	857
Alfalfa, Ladino clover	48	1806	939	867
Birdsfoot trefoil, sweet clover	49	1506	768	738
Birdsfoot trefoil	61	1442	562	880
	Grasses			
Timothy	68	2331	746	1585
Tall oat grass	58	2007	843	1164
Orchard grass	46	1808	976	832
Reed canary grass	42	1796	1042	754
Tall fescue	37	1733	1055	678
Bromegrass	26	1633	1208	425

Renovation of Unproductive Mountain Side Pasture. An additional renovation plot primarily for observation data was established on an old, abandoned hay field on a mountain side about 10 miles from State College. The soil was thin and unproductive and the vegetation consisted primarily of weeds and poverty grass. The field was disked twice in October with an ordinary field disk. Lime and fertilizer were applied and the field disked again. Seeding was done on frozen ground the following spring. No yields were taken in 1944 but good stands of sweet clover and Ladino clover and fair stands of alfalfa, red clover and birdsfoot trefoil were obtained. Orchard grass and tall oat grass made the best growth the first year, with timothy, reed canary grass, and bromegrass next and in that order. While this was an extremely poor field at the outset, it appeared that where fertilizer and lime were added it would be quite productive in spite of the thin rocky nature of the soil. Even though the field was on a slope, there was no evidence of erosion during the winter and spring--undoubtedly due to the sod and stubble left in the surface layer after disking.

PASTURE RENOVATION EXPERIMENTS (WITH RHODE ISLAND)

Title: Pasture Renovation Trials in Rhode Island.

Leaders: For the Rhode Island Agricultural Experiment Station - B. E. Gilbert and Irene H. Stuckey.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

In spite of drought, progress was made with pasture renovation experiments during the summer of 1944. On the area which had been prepared for seeding by lightly disking in the fall of 1942, clipping weights and percentages of legumes showed that poor seedbed preparation may be a major cause of failure in pasture renovation. At one end of the original area the sod was dense and at the other end thin and scattered. On the thin sod, excellent stands of red clover, sweet clover and alfalfa were established and persisted through the second dry summer. On the areas where the original stand of grass was dense, competition with the grass prevented the legume seedlings from becoming established during the first summer and by the end of the second summer, only grass remained.

At another location where the sod has been thoroughly disked the previous fall, three mixtures of grasses and legumes were seeded April 11 on replicated strips:

1.	2.	3.
Alfalfa	Red clover	Red clover
Ladino clover	Alsike clover	Ladino clover
Timothy	Ladino clover	Orchard grass
Bromegrass	Reed canary grass	
	Timothy	

Excellent results were obtained with all three mixtures and a total of approximately 100 cow days per acre grazing was obtained in spite of unfavorable weather conditions and without overgrazing the clovers. Most of this forage was obtained in July but in all cases the recovery after grazing was excellent. The weeds were somewhat troublesome early in the season but after one mowing did not offer serious competition to the seeded species. Sufficient growth was left in September to assure adequate winter reserves. As was to be expected during a season where palatable grazing was not too abundant, the forage on this pasture was eaten with relish. It was observed, however, that reed canary grass did not appear to be quite so acceptable as orchard grass, smooth bromegrass, or the legumes, where the cows had ready access to all species.

PASTURE RENOVATION EXPERIMENTS (WITH VERMONT)

Title: Pasture Renovation Trials in Vermont.

Leaders: For the Vermont Agricultural Experiment Station - A. R. Midgley and D. E. Dunklee.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson.

1. Relative value of different plants: these pasture renovation trials were seeded in early spring of 1943 on run-down pasture land that had been fall disked, limed and fertilized. Very good stands of legumes were established and excellent pasture produced during the summer of the seeding year. The clovers winterkilled rather severely that winter (1943), but very good stands of alfalfa remained. This is essentially good alfalfa land with a calcareous subsoil. The reduction in legumes was probably caused by too late grazing in the fall during the first year. However, there were still sufficient legumes to make good pasturage the following year as is indicated below:

	Pounds of dry matter per acre (1944)
Alfalfa and bromegrass	4300
Red, alsike clover and timothy	2230
Sweet clover and reed canary grass	2110
Ladino clover and orchard grass	1810
Birdsfoot trefoil and timothy	1530
Fertilizer only, no seed	1540
No treatment, original sod	920

While fertilizer alone has given a substantial increase, it is very evident that the extra cost of disking and seeding is well worthwhile. Fertilizer alone increased pasturage by more than a third but disking and seeding, in addition, increased it from two to four times.

LEGENDS FOR ILLUSTRATIONS
(Opposite page)

Upper photograph.

Unproductive permanent pasture in early July consiting of bentgrass, Canada bluegrass, poverty grass, Kentucky bluegrass and weeds. This is typical of many pastures which would respond to renovation practices.

Center photograph.

Preparation of the seedbed in midsummer immediately following a rain. The large cutaway disk heavily weighted is particularly well adapted for cutting up the sod and killing the existing vegetation.

Lower photograph.

Foreground: Original sod limed and fertilized but not disked or seeded.

Background: Legume-grass mixtures in June 1944 which were seeded on frozen ground in March 1943. The seedbed was prepared by liming, fertilizing, and disking in 1942, as shown in center photograph.

The sweet clover beetle (Systena frontalis) checked the growth of sweet clover. This insect makes it very difficult to grow this plant successfully in this section as it seems to be present everywhere.

Since most of the clovers, especially red, alsike, and sweet clovers, will be completely gone at the end of the second year, it is planned to try to reestablish them on their respective plots without additional tillage. In the fall of 1944, 500 pounds of 0-20-20 fertilizer was applied over the fertilized areas and they were closely and heavily grazed late into the fall in order to check the growth of competing grasses. These will be seeded in early spring on frozen ground and grazed closely again as early as possible to further check the grass. After the legumes are established, grazing will be deferred until later in the summer. A resonably good growth of vegetation will be left for winter protection similar to that for a newly established meadow.

2. Time of seeding: studies are being conducted to determine the value of late fall versus early and late spring seeding of fall disked pasture land. It may be more convenient to seed in late fall (November) and thus reduce the spring rush of work if satisfactory stands can be obtained. For successful seedings of legumes in late fall, it is quite likely that they should be made after the ground is very cold in order to prevent germination until the following spring. If the seeds remain dormant over winter, they may become covered better in the soil by alternate freezing and thawing and thus produce a better spring growth.

Plots were established on run-down pasture land that was disked, limed and fertilized in the fall of 1944. Half of each plot was seeded November 15, the other half will be seeded in early March to each of the following legumes: Ladino clover, red clover, sweet clover, alfalfa, and birdsfoot trefoil. In another field trial, a mixture of grass and clovers was planted about November 15 and will be compared to similar plantings in March as well as in May with the regular time and seeding method.

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING

Fertility Studies in Dactylis glomerata and Trifolium repens

Inheritance of Male Sterility in Dactylis glomerata. Crosses were made in the greenhouse in 1943-44 to provide seed for F_2 and backcross progenies for analysis of the inheritance of male sterility (1942 Annual Report, Page 16). The material planted previously for this study was lost due to winterkilling during the winter of 1942-43 (1943 Annual Report, Page 24). In the spring of 1944, 96 F_2 and 35 backcross progenies were transplanted to the nursery. Including parental and F_1 checks, the planting consisted of over 6400 plants. These plants became well established during the summer and should be available for classification in 1945.

Among the plants used for studying inheritance of young plant characters (page 36), 17 were found to be male sterile, i.e., the anthers did not dehisce. The cytogenetic basis for male sterility in these plants is being investigated.

Inheritance of Male Sterility in Trifolium repens. When a plant of white clover was found that appeared to have a type of male sterility conditioned by other than morphological causes (1943 Annual Report, page 31), several crosses were obtained with this plant, using it as female. Two of the resultant F_1 families were grown in the greenhouse and tested for self- and cross-incompatibility. In one family of 13 individuals, all plants were self-incompatible, and two intra-sterile, inter-fertile groups were observed following diallel crossing. In the other family of 13, similar results were obtained except that one F_1 plant was completely male sterile like its female parent. Selected F_2 and backcross families are now being grown in an attempt to determine the factors causing this male-sterile condition.

Variations in Self-fertility in Trifolium repens. In the source nursery of Ladino clover, planted in the spring of 1943, over 650 plants were bagged and manipulated for the production of selfed seed in the summer of 1944. Four bags, each enclosing two heads, were used on a plant. Summary of the data on number of seeds per head is not yet completed but it is evident that the seed set was low, the range in self-fertility being similar to that found in white clover.

Behavior of Oppositional Alleles in Polyploids. In an attempt to obtain additional data on the hypothesis used to explain self- and cross-incompatibilities in polyploids (1943 Annual Report, page 33), 14 F_2 and backcross progenies with a total of 559

individuals were grown in the greenhouse, where each plant was self-pollinated and crossed with certain tester plants. In most of the segregating families, the differences in average seed sets between self-compatible and self-incompatible plants were large, so that little difficulty was experienced in distinguishing these two types, but in very few cases did the the obtained ratios SI/SC fit the expected based on the simplest assumptions. Several alternative hypotheses are suggested by these results, however, and all the data are being reanalyzed in an effort to ascertain the most probable explanation.

Most of the results were of the same type as those found in the F_1, suggesting that the same genetic mechanism is operating throughout. One of the most striking features of these results was the wide variation in degree of self-compatibility found among the different self-compatible plants. In all 14 families significant differences were found in average number of seeds following selfing of self-compatible plants.

In a second F_1 family from a 64 x 64-chromosome cross, in which the female parent was the same plant as that used as female in the first cross, an entirely different type of results was obtained. All 40 F_1 plants were self-incompatible, and almost all intercrosses were incompatible, with no indication of a pattern of compatible and incompatible matings such as were found previously. All backcrosses using the female parent as male were incompatible, but some seeds were obtained in most of the reciprocal crosses. On the other hand, when the 40 plants were crossed reciprocally with the three self-incompatible plants found in the other series, good seed set was obtained in almost every case.

Varietal Improvement in *Dactylis glomerata*, *Poa pratensis*, *Festuca elatior*, *Sorghum vulgare* var. *sudanense*, *Bromus inermis*, *Trifolium repens* and *Medicago sativa*

Most of the investigations relating directly to the improvement of orchard grass, Kentucky bluegrass, and white clover have been incorporated in the cooperative breeding projects with these species (pages 5 to 10, inclusive).

Inbreeding in Dactylis glomerata. Selfed seed was obtained from one or more plants in most of the I_3 lines planted in the fall of 1942 (1942 Annual Report, page 18). This seed will be used in the spring of 1945 for plantings designed to solve certain fundamental problems related to the feasibility of inbreeding as a method for improving orchard grass. In the spring of 1944, plants of 71 I_1, 5 I_2, 30 I_4, and 32 F_3 lines were transplanted to the nursery.

Inbreeding in Sorghum vulgare var. sudanense. Inbreeding was continued in Sudan grass, using seed obtained in 1943 (1943 Annual Report, pages 24 to 25). The lines available have been inbred from two to seven generations and have been reduced from the original number to approximately 75 by selection for disease resistance, vigor as measured in clipping experiments, and by failure to obtain viable seed. Poor seed set was obtained in 1944 due to lateness of maturity which resulted from late planting and an unfavorable season. To insure sufficient inbred seed to maintain the lines, plants from each inbred line were transplanted, prior to the first frost, to pots in the greenhouse and selfed seed has been obtained from most plants. The studies on incidence of natural crossing in Sudan grass were completed and the data were summarized for publication (page 64).

Inbreeding in Trifolium repens. As a result of severe winter injury during 1943-44, very few of the inbred plants of white clover established in the nursery in 1943 (1943 Annual Report, pages 34 and 35) were alive in the spring of 1944. Consistent with the plans to reduce somewhat the breeding program with this species, no effort is being made at the present time to replace these lines by use of reserve seed.

Selfed seed was obtained in 1943 from one or more plants of 156 I_2 and I_3 lines of white clover (1943 Annual Report, page 35). I_3 and I_4 progenies of one plant from each I_2 and I_3 line, respectively, were established in the nursery in the spring of 1944. In order to provide a measure of the breeding value of these inbreds, the lines were distributed at random in six replications in a polycrossing block. The lines will be maintained by selfing and open-pollinated seed will be harvested to provide a progeny test of the combining ability of the individual lines. Superior lines will be utilized in the production of new strains and the remainder will be discarded.

An F_2 progeny, consisting of 30 plants, was established from a single plant in each of the F_1 progenies resulting from crossing apparently superior clones of white clover with S_fS_f plants (1943 Annual Report, page 35). These inbred progenies will be utilized primarily for studies of the feasibility of using the S_f gene for facilitating the inbreeding program.

Seed was obtained in the greenhouse from crosses of 56 selected Ladino clover clones with the S_fS_f plants (1943 Annual Report, page 36). Ten plants from each cross were established in the nursery in the spring of 1944. These crosses were designed to introduce the S_f factor into Ladino clover, thereby facilitating the production of inbred lines. Since the S_fS_f parent was white clover, the success of such a program of hybridization and subsequent selfing will be dependent upon the relative simplicity of inheritance of the complex of characters differentiating white and Ladino clover. If only a few factors are involved, it may be

possible to produce Ladino-like inbreds by inbreeding from F_1 plants. On the other hand, if many factors are involved, the resultant inbreds will be intermediate between white and Ladino clover. In the latter case, it will be necessary first to incorporate the S_f gene into Ladino. A study, designed to determine the inheritance of the differences between the two clovers, is outlined on page 37.

Evaluation of Clones of Trifolium repens in Plots. Observational data were collected on the plots of 25 clones of white clover planted in association with Kentucky bluegrass (1943 Annual Report, page 36). Significant differences were found among clones in rate of establishment, amount of growth and habit of growth. Several of the clones appeared quite outstanding in competitive and yielding ability. Open-pollinated seed was harvested from the eleven best clones and from four clones that were below the average in performance. This seed will be used for planting broadcast plots in association with Kentucky bluegrass to test the general combining ability of the clones.

Observational data were taken also on the plots of 242 clones of Ladino clover planted in association with orchard grass (1943 Annual Report, page 36). Significant differences were found among clones. Much of the difference may have resulted, however, from differential rate of establishment for the differences were less extreme in the fall of 1944 than in the spring or summer. Data will be collected from these plots again in 1945. Meanwhile, to provide seed for a test of combining ability of the clones, open-pollinated seed was harvested from 62 of the best clones and, for comparative purposes, seed was harvested also from 20 clones that were below the average in performance. Sufficient seed for planting broadcast plots was obtained from most of the 62 best clones but from only four of 20 poorer clones. These plots will be established in association with orchard grass in the spring of 1945.

New Selections of Trifolium repens. From the nursery of over 3,000 plants of Ladino clover established in the spring of 1943 (1943 Annual Report, pages 36 and 37), 267 plants were selected on the basis of winter survival, vigor of growth, spreading ability, disease resistance, and drought and heat resistance. These plants are being grown in the greenhouse for clonal increase and the clones will be planted in a polycrossing plot in the spring of 1945.

Combining Ability of Sod Plot Selections in Trifolium repens. Observational data were taken from plots established in the spring of 1943 (1943 Annual Report, page 36) to test combining ability of the clones of white clover selected as good, medium, and poor on the basis of behavior in clonal plots. Differences among crosses were observed in rate of spread, vigor and growth

habit. As a result of the lateness of seeding and the dry summer of 1943, the bluegrass did not become well established in these plots until late in 1944. Consequently no evidence is yet available on the relative competitive ability of the crosses.

Evaluation of the New Strain of Ladino Clover. Because of the small amount of seed obtained in 1943 from the eight clones of Ladino isolated under bee cages (1943 Annual Report, page 37) it was impossible to seed broadcast plots of this strain as planned. Consequently, seedlings of the new strain and of commercial Ladino clover were started in flats in the greenhouse and transplanted to replicated plots, 4 feet by 16 feet, in the field. The seedlings were spaced one foot apart within the plot and six replications were used. Orchard grass was broadcast uniformly over the entire area.

Evaluation of Plant Types in Poa pratensis. Observational data were collected from the preliminary plot tests of Kentucky bluegrass strains (1943 Annual Report, page 24). Significant differences were again obtained in earliness of growth in the spring, recovery following clipping, and estimated yield. Only a few of the new selections were equal or superior to the better of the two check strains. These plots will be continued through another year at least before strains are selected for evaluating in larger plots where actual yields are taken.

Strain Trials of Poa pratensis. The experiment described previously (1942 Annual Report, pages 19 to 23 and 1943 Annual Report, page 26) was continued. The plots were clipped three times, May 13, June 7 and August 15. As a result of the unusually severe drought, the Kentucky bluegrass made very little growth after the clipping on August 15. Statistically significant differences among strains were obtained at the May 13 and June 7 clipping for total yield, calculated yield of white clover, per cent of white clover and per cent of weeds. At the August 15 clipping, the strains were significantly different in yield of bluegrass and per cent of weeds but not in the other characters.

Only one selected strain, KB143(223), excelled the better commercial check in yield of grass, total yield and yield of grass plus clover. This strain has been highest in yield in each of the three years. The higher yielding commercial check and four other selected strains exceeded KB143(223) in yield of associated white clover but in only one of these, KB170(3), was the difference large.

In general, the reaction of the strains was similar to that obtained in the two preceding years. The taller-growing types were higher in yield of grass than the short, dense sod-forming types but in plots of the latter, the stand of white clover was

better, compensating to a considerable extent for the differences in yield of bluegrass. Striking exceptions were encountered however. KB143(223), a high yielding strain, has already been discussed. Another tall strain, KB114(12), produced about the same yield of grass as KB143(223) but, consistent with its previous behavior, it competed strongly with the white clover. The yields of white clover and weeds in plots of this strain were lower than in any others. KB181(1) and KB120(30), dense sod-forming types, also had excluded the weeds rather effectively and the former was among the lowest strains in amount of associated white clover. The latter two strains may be valuable for use in lawns.

Production of Improved Strains of Festuca elatior. From 90 to 200 grams of seed were obtained from each of the 15 isolation plots of meadow fescue (1943 Annual Report, page 27). Sixty seedlings from each strain were space planted in the field to provide a source nursery for further selection. Broadcast plots of the strains will be seeded in the spring of 1945.

Single panicles were collected from 25 of the best plants in the wild stand on the Thornton farm near State College, Pennsylvania (1943 Annual Report, page 29). The plants were found by cytological analysis to be of the tall fescue type. Progeny plants from each panicle were space planted in an isolated part of the nursery to provide material for production by mass selection of a new strain of tall fescue.

Through the courtesy of Doctor F. H. Steinmetz, Maine Agricultural Experiment Station, seed of meadow fescue was obtained from an old meadow near Orono, Maine. Three plants from that collection were tested for resistance to crown rust (1943 Annual Report, page 62) and proved to be immune even when inoculated in the greenhouse. Since these plants were the only immune ones among the large number of diploid plants tested, additional seed was obtained from Doctor Steinmetz. Young plants from 45 individual panicles were inoculated in the greenhouse. Among the progenies of some panicles, all plants were immune, in other progenies all plants were susceptible, while in several progenies both immune and susceptible plants occurred. These plants are being reinoculated to eliminate any that may have escaped infection in the first inoculation. Immune plants will be planted in an isolated area in the field in the spring of 1945 to provide seed of a crown rust immune strain.

In contrast to the high incidence of susceptibility to crown rust among diploid (ordinary meadow fescue) plants, all plants of the hexaploid (tall fescue) type tested to date have been immune from the disease. Variations from a high degree of resistance to complete susceptibility to net blotch (Helminthosporium dictyoides)

have been found among plants of both diploid and hexaploid types. Crosses are planned for the greenhouse in 1944-45 to provide material for studies of inheritance of reaction to these two diseases.

Production of Improved Strains of Bromus inermis. Small quantities of seed were harvested from each of the four isolation plots of bromegrass (1943 Annual Report, page 27). Plants from this seed were included with those from additional collections to make a new space-planted source nursery of approximately 2,000 plants.

Genetical Investigations

Inheritance of Rust Resistance in Phleum pratense. After two unsuccessful attempts, sufficient seed was obtained in 1943 for the production of F_2 and backcross progenies to study further the inheritance of stem rust resistance in timothy (1940 Annual Report, page 20). In the fall of 1944, a space-planted nursery of about 4,000 plants from 170 F_2 and backcross progenies was established in the field.

Interspecific Hybrids in Poa. F_3 progenies from open-pollinated seed of 21 F_2 plants of Poa compressa x P. pratensis were established in the field in the fall of 1943 (1943 Annual Report, page 28). Data on progeny uniformity were taken in 1944. In one progeny, the plants were uniformly of one type, indicating apomictic reproduction in the parent. Extreme segregation in each of the other progenies indicated sexual reproduction of the F_2 plants. Sexual reproduction in F_1 and F_2 of this hybrid was unexpected since both parents were almost completely apomictic in reproduction. It is evident that apomixis in Poa is conditioned by genes and is not the result of hybridity.

Heritable Young Plant Characters in Dactylis glomerata. To provide material for testing the allelism of mutant types from different inbred progenies (1942 Annual Report, page 24), approximately 1,000 crosses were made in the greenhouse in 1943-44. Five seedlings from each of 433 of these crosses were established individually in 3-inch pots in the fall of 1944. Very few of the F_1 progenies showed the mutant characteristics of the parents. On the other hand, segregation of the F_1 for other mutant types was common, indicating that the parents were heterozygous for other genes conditioning simply inherited young plant characters. Intercrosses will be made among F_1 plants of each cross to provide seed for an F_2 generation.

Adult Plant Characters in Dactylis glomerata. When the plants used for studying inheritance of young plant characters were grown to maturity in the greenhouse, it was observed that soon after flowering many of them showed various types of leaf

necrosis, ranging from tiny white flecks to large brown or yellow patches that killed the entire leaf. Certain plants had leaf spots resembling those caused by Stagonospora subseriata var. maculata but attempts to isolate a causal organism from the spots were unsuccessful. Since these plants were used in crosses for studies of inheritance of young plant characters, material will be available also for investigating inheritance of the adult plant characters.

Inheritance of Size Differences in Trifolium repens. Taxonomically, Ladino clover is classified in the same species as white clover. Cytological and fertility relationships support the systematic procedure. Ladino clover differs from white clover in a complex of size characters--size of stolons, petioles, leaflets, flower heads and flowers. Although intermediate forms apparently occur and the ranges probably overlap, it is apparent that white and Ladino clover form two distinct frequency distributions so far as size characters are concerned. Such divergence within a species without a preponderance of intermediate types is not a common occurrence.

For a better understanding of this phenomenon and to provide information essential for planning the breeding program, a genetic analysis of the complex of size characters differentiating white and Ladino clover seems necessary.

For use in the study, F_1 plants of selected Ladino clover clones x self-fertile white clover clones were available (1943 Annual Report, page 36). Plants of F_1 and parents from selected crosses are being grown in the greenhouse for production of F_2 and backcross seed.

Inheritance of Leaf Markings in Trifolium repens. In previous years the inheritance of leaf markings in white clover has been investigated (1943 Annual Report, page 37; 1942 Annual Report, page 36). In Ladino clover, several modifications of the V-marking have been observed. These include double V, absence of the point, absence of the sides, shape, and color of the V. The need for useful marker genes to facilitate the cytogenetic analysis of Ladino clover and the desirability, if possible, of finding markers for identifying new strains, have led to a study of inheritance of the various types of leaf markings. Clones are being grown in the greenhouse for use in crosses for the genetic analysis.

Inheritance of Rust Resistance in Trifolium repens. From the crosses made in 1943-44 (1943 Annual Report, page 38), approximately 1,200 plants were spaced in the nursery in the spring of 1944. These were included in eight crosses of resistant x resistant, 23 of resistant x susceptible, and 23 susceptible x susceptible. It is expected that this material will be classified for rust reaction in the summer of 1945.

Genetics of a Heritable, Virus-like Injury. Since there were several inconclusive features in both the F_2 and backcross results (1943 Annual Report, page 38), certain plants were selected from these families and backcrossed to both original parents in order to obtain a progeny test. A total of 1,915 progeny plants were grown in the greenhouse and classified for presence or absence of disease. In general, the results obtained from this progeny test confirmed the previous hypothesis of two independent factors, both of which must be present for the development of the necrotic lesions.

The differences between the several segregating ratios in average leaf number at the age of six weeks were found to be highly significant both among the healthy and among the diseased types. These averages were inversely correlated ($r = -0.944$) with the number of dominant factors borne by the different classes, indicating a highly significant dosage effect expressed in vigor and caused by the same genes that conditioned mottling. In other words the dosage effect was superimposed on the sharply bilateral segregation observed with presence or absence of disease.

Cytological Investigations

Origin of Aneuploidy in Dactylis glomerata. Extensive cytological studies of orchard grass have revealed that this species behaves in meiosis like an autotetraploid (1942 Annual Report, pages, 25, 26, and 29 to 32). Variations among plants in frequency of irregularities of meiosis were observed and these irregularities were correlated with infertility of the various plants. It is expected that the irregularities of meiosis, since they cause the production of aneuploid gametes, will be responsible also for the origin of aneuploid plants (plants with more or less than the normal number of 28 chromosomes). To test this hypothesis, approximately 1,000 plants have been established consisting of 100 plants from open-pollinated seed obtained from each of 10 plants ranging from low to very high incidence of meiotic irregularity. The cytological analysis of these plants is not completed. Chromosome numbers have been determined from root tips of 404 plants. The percentage of aneuploids found in different progenies ranged from 5 to 27 per cent. Among the 404 plants, one had 26, 25 had 27, 23 had 29, 2 had 30, 2 had 31, and 3 had 42 chromosomes. Open-pollinated seed was obtained from one of the plants with 42 chromosomes. Most of the plants from that seed had 35 chromosomes; the remainder had 33 or 34. Thus, the seed must have been produced with pollen from normal tetraploid plants. The aneuploid plants (with 26, 27, 29, 30, 31, 33, 34, and 35 chromosomes) are being intercrossed and backcrossed to plants with 28 chromosomes to provide material for studying the frequency of transmission of the various tri- and pentasomics and for the establishment of additional pentasomic and hexasomic types.

Chromosome Numbers in Festuca elatior. Single panicles were collected from additional plants of the stand of Festuca elatior from which the previously collected plants (1943 Annual Report, page 29) had proved to be hexaploid (2n = 42). Root tip chromosome numbers were determined for one plant from each panicle and all plants proved to be hexaploid.

Since both diploid (2n = 14) and hexaploid (2n = 42) types of F. elatior have been found in the United States and, in addition, tetraploid and decaploid types have been reported from Europe, it seemed desirable to know the chromosome numbers of strains available in this country. Through the courtesy of Mr. M. A. Hein, seed of seven strains included in the Uniform Grass Nurseries was obtained. Twenty plants were established in the greenhouse from each strain and the chromosome number of each plant was determined from root tip sections. Two of the strains proved to be hexaploid as follows:

F. elatior-3. F.C. 29,366, "Alta" fescue, a strain of tall fescue.

F. elatior-4. Ky. Sta. No. K-31. Suiter strain of tall fescue.

Four of the strains proved to be diploid as follows:

F. elatior-1. Originally S-53 from Wales (English grazing strain). Seed obtained from Soil Conservation Nursery, Big Flats, New York.

F. elatior-5. Svalof early meadow fescue seed from Massachusetts where the strain is reported to be resistant to leaf rust.

F. elatior-6. Minn. 1449. Selection from northern-grown commercial seed.

F. elatior-7. Otofte meadow fescue. Seed from Massachusetts.

In one strain, New York Sta. No. 2659, 19 plants were hexaploid and one was diploid. This strain is classified morphologically as tall fescue.

Four plants of the diploid type were each found to have a single centric fragment. A more detailed study of the characteristics and behavior of these fragments is in progress.

Origin of Natural Polyploids in Festuca elatior. In planning effectively a breeding program involving a polyploid species, the question of origin of the species, whether by auto- or allopolyploidy, is of critical importance (1942 Annual Report, pages 25 and 26). Thus, the problem of the origin of hexaploid Festuca elatior (tall fescue) has arisen. In the five plants investigated to date, quadrivalents have been found at diakinesis and metaphase I of meiosis in each plant, the frequency per sporocyte ranging from one to five. In the F_1 of perennial

ryegrass (14 chromosomes) x hexaploid tall fescue, there was, at meiosis, an average of 1.25 univalents, 8.4 bivalents, 0.6 trivalents, and 2.0 quadrivalents per sporocyte. The number of univalents varied from 0 to 3, the number of bivalents from 5 to 12, and the number of quadrivalents from 0 to 4. The results indicate considerable homology between perennial ryegrass and tall fescue chromosomes and, in addition, between chromosomes of the genomes of tall fescue.

Hybrids between diploid (meadow fescue) and hexaploid (tall fescue) types of Festuca elatior have been produced and are being grown in the greenhouse to provide material for cytological analysis and to test fertility and other characters of the hybrids.

Colchicine Induced Autotetraploidy in Lolium perenne, Festuca elatior and Dactylis aschersoniana. The separation of diploid and tetraploid tissue by single tiller isolation from perennial ryegrass plants obtained from colchicine treated seeds was continued (1942 Annual Report, pages 28 and 29). There was no noticeable tendency for either diploid or tetraploid tissue to be eliminated by the other and no observable differences in ease of obtaining pure diploid or tetraploid material. Mixtures of diploid and tetraploid tissue persisted in some clones through seven vegetative generations in each of which selection was based upon root tip determinations of chromosome number. These were preceded by four generations of vegetative propagation, making a total of 11 generations. The results have been summarized for publication (page 64).

The process of vegetative increase using single tiller isolation to separate in pure form diploid and tetraploid clones of meadow fescue (1943 Annual Report, page 30) has been continued through the fourth generation. In some clones, only 2x or 4x root tips, as expected, have been obtained for two or more generations. These clones are judged to be pure. In other clones, the presence of both diploid and tetraploid root tips indicated that the plants are still mixoploid.

Cytological and genetical evidence indicates that orchard grass (Dactylis glomerata) is an autotetraploid and that it may have arisen by chromosome doubling from a diploid, wild, European species, D. aschersoniana. If so, doubled forms of D. aschersoniana should resemble D. glomerata and be cross fertile with it. Furthermore, cytological studies of such doubled forms should provide evidence of changes that have occurred in D. glomerata since its origin which permit it to persist as a sexually reproducing autopolyploid.

Several years ago, 50 seeds of D. aschersoniana were obtained from Sweden through the Division of Foreign Plant Introduction. From these, three plants were obtained, two of which were diploid. From these two plants and their progeny, several

hundred seeds were obtained and were available for use in 1944. Six hundred were treated with solutions of colchicine and 43 seedlings were obtained. Three were mixoploids of diploid and tetraploid tissue. From subsequent treatments over 200 additional seedlings have been obtained but have not yet been studied cytologically. The mixoploid plants are being increased vegetatively to provide pure diploid and tetraploid clones for further study.

Comparative Meiotic Behavior of Diploid and Tetraploid Lolium perenne. Using pairs of diploid and tetraploid clones obtained from single mixoploid plants of perennial ryegrass, the analysis of meiotic behavior in autopolyploids (1942 Annual Report, pages 29 and 30) was continued. Plants from 14 pairs of clones were used in the study. As compared with the diploid clones, there was in the tetraploids a delay of chromosome contraction relative to the onset of metaphase I and in two clones absence of orderly orientation on the equatorial plate prior to the initiation of anaphase I. In some pairs, the chiasma frequency of the tetraploid clone was lower than in the diploid while in other pairs the differences between tetraploids and diploid were not significant.

There were three major types of meiotic irregularity in the tetraploid clones, namely, (1) the members of the quadrivalents frequently disjoined unequally at anaphase I, (2) lagging and dividing univalents at anaphase I resulted in some cases from incomplete disjunction of quadrivalents, and (3) there was a high incidence of univalents at metaphase I that tended to lag and divide equationally at anaphase I and to be left in the cytoplasm at telophase I and telophase II. Each of these irregularities would result in production of aneuploid and genetically unbalanced gametes which have in turn been found to be a cause of sterility and aneuploid progeny plants.

It was not possible in this material to predict the meiotic behavior of the tetraploid clone from that of the diploid.

Several of the important forage grasses behave cytogenetically as autopolyploids, while in many others some homology between chromosomes from different genomes is found. Such species have certain irregularities of meiosis that result from the tendency for multivalent pairing. Any factor that would tend to inhibit the multivalent association would on the average result in greater stability and fertility of the species. Chromosomal rearrangements, particularly inversions, have been postulated to be the most important kind of chromosomal differentiation that would lead to regular bivalent instead of multivalent formation.

In this material, the presence in each of the diploid clones of heterozygous inversions that were duplex in the related tetraploid clone provided a means of testing this hypothesis.

It was concluded that inversions of the size found in this material did not appreciably inhibit randomness of chromosome pairing and, hence, were not an important factor in conditioning bivalent instead of quadrivalent formation.

The results of these investigations have been prepared for publication (page 64).

Winterhardiness of Diploid and Tetraploid Clones of Lolium perenne. Winterhardiness is a critical factor in the ability of many clones and strains of perennial ryegrass to persist at State College, Pennsylvania, and improvement in that regard would be a valuable contribution to the usefulness of this species. The tendency for polyploid species in nature to occupy areas with less favorable climatic conditions and to extend into more northern latitudes than their diploid relatives has led to the assumption that chromosome doubling might result in greater winterhardiness and drought tolerance. If so, autotetraploids of perennial ryegrass might be valuable for extending northward the range in which this species would be useful as a forage plant.

In the spring of 1943, eight pairs of diploid and tetraploid clones were space planted in the field in rows of 10 plants each, distributed at random in four replications. All plants were well established by fall and the winter of 1943-44 was not unusually severe as judged by winter injury in the orchard grass nursery. Nevertheless, winter injury was evident in each of the tetraploid clones. In some pairs, the diploid clones were injured while in others there was no evidence of injury. In each pair and consistently in each replication, the tetraploid clone was more severely damaged than the diploid. In one pair all plants of the tetraploid clone were completely killed.

Improvements in Cytological Techniques. In connection with cytological investigations at the Laboratory, it frequently has been desirable to determine the chromosome numbers of a large number of different plants. Adding to the problem is the fact that chromosomes of some of the grasses are long and consequently accurate determinations are difficult or impossible with ordinary methods of preparing root tip sections for study. For handling the root tips from large numbers of plants, Randolph's card method has been modified by substituting for the first card, small (25 x 8 mm.) vials supported in order by indentations in small wooden blocks. The tips, when removed from the fixing solution are brushed clean in a Petri dish of water, cut to the desired length and arranged in an orderly manner on blotting paper moistened with 50 per cent alcohol. They are then glued on 7 by 12 mm. cards and placed immediately into 50 per cent alcohol. Changing of solutions is facilitated by placing the cards bearing the root tips onto

a circular flat wire tray (hardware cloth with 1/4 inch mesh) which fits into covered preparation dishes. From 20 to 30 cards (6 root tips per card) may be placed on this tray and the alcohols changed merely by transfer of the tray and cards to dishes containing the desired solutions.

Exposure of the root tips prior to removal from the plant to temperatures of 0 to 2° C. for 24 hours was found to result in contraction of the chromosomes to such an extent that readily interpreted figures were obtained in most plants. To provide straighter, cleaner tips from younger roots and to facilitate cold treatment, one to three tillers are broken from each of the desired plants, the old roots are trimmed away, the tillers suitably labeled and placed in tap water in 150 ml. beakers for the production of new root tips. Tillers of 8 to 10 plants may be placed in a single beaker. The water is changed daily and maintained at a depth of 12 to 18 mm.

The improvements in technique have been submitted for publication (page 64).

Further Studies of Irregularities of Meiosis in Dactylis glomerata. Replicated plantings of first inbred generation plants of three families were established in the field in the spring of 1944 to provide material for further studies of the interrelationships of irregularities of meiosis and the effects of inbreeding upon the irregularities (1942 Annual Report, pages 29 to 32). Inbred seedlings were established in the greenhouse and allowed to grow until several tillers were produced on each. The plants were then propagated vegetatively to provide four plants from each original plant. These plants were planted at random in four replications. A row of 10 plants from the parental clone was planted in each replication. It is expected that this material will be available for study in 1945.

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

Photoperiodic Responses of Several Pasture Species

Work previously reported (1942 Annual Report, pages 42 and 43, and 1943 Annual Report, pages 42 to 44) has indicated that breaking the normal winter 14-hour dark period into two 6-1/2 hour dark periods with one hour of supplementary light was about as effective in initiating heading of several pasture species as was a continuous 16- or 17-hour day. During the winter of 1943-44 additional trials were conducted to evaluate more adequately the response of orchard grass, meadow fescue and white clover to an interruption of the normal 14-hour dark period with supplementary light. For this purpose, a number of individual plants (between 34 and 100) of each of the above species were grown for several

months under the normal short winter daylengths and then given two light treatments: (1) continuous 16-hour day by supplementing the normal winter daylight with 6 hours of Mazda light, and (2) by breaking the normal 14-hour night with one hour of Mazda light from 12:30 to 1:30 a.m., Eastern War Time. The results of these trials are summarized in Table 5. It is apparent that the short light interval breaking the dark period was as effective as the continuous long day in initiating flowering of meadow fescue and white clover. In the case of orchard grass, the slightly better heading under a continuous 16-hour day is of doubtful significance.

Vegetative Responses of Several Grasses and Legumes to Supplementary Light

Data previously reported (1943 Annual Report, pages 45 to 47) showed the response of 14 plant species to length of light period and length of dark period during November and December. Studies were continued to determine the responses during February and March when the natural days are not only longer but brighter. Tht total foot-candle hours of light as measured by the integrating light recorder (1941 Annual Report, page 55) were 4,002,657 during February and March of 1944 as compared with 2,840,420 during November and December of 1943.

Higher yields were obtained during February and March than during November and December, particularly with Ladino clover, Kentucky bluegrass, and redtop. The total yields of these species were two to three times higher than in November and December, whereas orchard grass, bromegrass and perennial ryegrass yielded only 40 to 50 per cent higher.

In general, the photoperiodic response was similar in the two trials in that increased daylength resulted in greatly elongated vegetative parts. In most species, however, the differences in yields of dry matter were small in comparison with the increase in degree of elongation. In fact, the greatly elongated plants of Kentucky bluegrass that were grown under a 17-hour day produced lower total yields of dry matter than plants grown under a natural day. Alta fescue was the only species in this trial in which no photoperiodic response was apparent (this species was not included in the trials conducted in November and December).

The root-top ratios of orchard grass, Kentucky bluegrass, and Sudan grass were not appreciably affected by variations in length of day but with the other species (except alta fescue) the root-top ratio decreased with increasing daylength.

Table 5. The heading and flowering response of orchard grass, meadow fescue and white clover to a continuous 16-hour day vs. a night broken by one hour of light near midnight.

	Orchard grass		Meadow fescue		White clover	
	16-hour day	Light at midnight*	16-hour day	Light at midnight*	16-hour day	Light at midnight*
Number of plants used	101	101	34	41	58	58
Per cent flowering	84	70	100	100	92	98
Number of heads per plant that flowered	3.9	3.8	6.4	6.6	27	20
Average number of days under lights until flowering	46	44	44	44	64	61

* One hour of Mazda light supplied in the middle of normal winter night.

The Effect of Temperature on the Emergence and Early Seedling Development of Hay and Pasture Plants

During 1944, an experiment similar to that previously reported (1943 Annual Report, pages 48 to 52) was conducted in order to determine the responses of eight additional pasture species to air and soil temperatures. The species used included reed canary grass, tall oat grass, perennial ryegrass, tall fescue, timothy, sweet clover, alsike clover and birdsfoot trefoil. The analyses of the data obtained in this trial have not yet been completed.

The Responses of *Dactylis glomerata*-*Trifolium repens* var. *latum* and *Bromus inermis*-*T. repens* var. *latum* to Ammonium Nitrate and to Height and Frequency of Cutting

The maintenance of the desired proportion of Ladino clover in association with a grass is a major pasture problem. Among important factors affecting this proportion may be mentioned soil moisture, available nitrogen, and time and height of defoliation. In studies at the Laboratory, time and height of cutting and to a lesser extent the application of nitrogen fertilizer in the spring are being studied to determine the effects of several management systems on (1) the total yield and seasonal distribution of the yield, (2) the percentage of Ladino clover in the stand throughout the season, and (3) the persistence of the clover and grass from year to year.

For this purpose one block of orchard grass-Ladino clover and one block of bromegrass-Ladino clover were seeded without a companion crop on a well prepared seedbed in May 1943. During that summer the areas were clipped high twice to control annual weeds. By fall a good sod of the seeded species had been obtained and at that time the area was top-dressed with 200 pounds of P_2O_5 and 200 pounds of K_2O per acre. In early April 1944, nitrogen as ammonium nitrate was applied to plots at a rate of 60 pounds of nitrogen per acre in one application.

The defoliation and nitrogen treatments were the same for both grass-clover associations and may be summarized as follows:

1. Clipped when 10 or 12 inches to 1 inch all season.

2. Clipped when 10 or 12 inches to 2 inches all season.

3. Clipped when 10 or 12 inches to 2 inches all season, plus nitrogen in spring.

4. Clipped when 10 or 12 inches to 3 inches all season.

5. Clipped at early hay stage to 1 inch, then at 10 or 12 inches to 2 inches the rest of the season.

6. Clipped at early head stage to 1 inch, then at 10 or 12 inches to 2 inches the rest of the season, plus nitrogen in spring.

7. Clipped at early head stage to 3 inches, then at 10 or 12 inches to 3 inches the rest of the season.

8. Clipped at full bloom stage to 1 inch, then at 10 or 12 inches to 2 inches the rest of the season, plus nitrogen in the spring.

9. Clipped at full bloom stage to 3 inches, then at 10 or 12 inches to 3 inches the rest of the season.

At each harvest date, samples were separated into grass, clover and weeds to determine the botanical composition of the herbage. Thus the dry-weight yields of the several species could be determined as well as the total yield of the plot.

Due to previous land use, one-half of the orchard grass-Ladino block contained what might have been estimated as an "ideal" mixture of the two seeded species. The other half of the block contained a good stand of orchard grass but a thin stand of Ladino clover. Since there was a sharp break between the two halves of the orchard grass-Ladino clover block, it was decided to include three replications of the management treatment on each half of the block to determine the effect of the several treatments both on maintaining a good stand where such existed and on bringing back Ladino clover into a thin stand.

As in many parts of the Northeast, rainfall was particularly limiting during July and August so that the number of harvests and the total yields obtained were below what might normally be expected. On September 29, all plots were cut at a 3-inch height in order to provide similar winter cover. The yield from this cutting was small and botanical separations of grass, clover, and weeds were not made. A general summary of the yields obtained during the first cutting year is presented in Table 6.

It is apparent from these data (Table 6) that, in all cases, nitrogen fertilizer increased the yield of grass and decreased the yield of clover. Most of the increase in grass yield occurred in the first cutting but the lowered yield of clover throughout the season and particularly on those plots which had a thin stand of clover at the beginning of the season.

The yield data from those plots cut at different heights and at different stages of growth indicate, at the end of the first season, little effect of height of cut except a slight reduction in total yield for the season at the 3-inch cut on those plots where the first cut was made early. However, observations made

Table 6. The effect of stage of growth and nitrogen on yield of orchard grass-Ladino clover and bromegrass-Ladino clover.

Clipping treatment	Total number of cuttings*	Pounds per acre oven-dry weight: Nitrogen applied in April	Ladino clover	Grass	Fall uniformity cutting**	Total
		Orchard grass - Good Ladino clover				
Approx. 10" to 2"	4	0	1320	2077	239	3636
Approx. 10" to 2"	4	60	570	3213	163	3946
Early head to 1", then 10" to 2"	4	0	1831	2201	168	4200
Early head to 1", then 10" to 2"	4	60	1040	3558	136	4734
Late head to 1", then 10" to 2"	3	0	1596	3068	225	4889
Late head to 1", then 10" to 2"	3	60	529	4432	127	5088
		Orchard grass - Thin Ladino clover				
Approx. 10" to 2"	4	0	354	2650	163	3167
Approx. 10" to 2"	4	60	124	3721	101	3946
Early head to 1", then 10" to 2"	4	0	685	2836	168	3689
Early head to 1", then 10" to 2"	4	60	152	4336	78	4566
Late head to 1", then 10" to 2"	3	0	430	3808	173	4511
Late head to 1", then 10" to 2"	3	60	136	4786	87	5009
		Bromegrass - Ladino clover				
Approx. 10" to 2"	3	0	762	1864	306	2932
Approx. 10" to 2"	3	60	437	2762	447	3646
Early head to 1", then 10" to 2"	3	0	1000	3875	141	5016
Early head to 1", then 10" to 2"	3	60	367	5049	143	5559
Late head to 1", then 10" to 2"	2	0	463	4283	306	5052
Late head to 1", then 10" to 2"	2	60	169	5274	392	5835

* Including uniformity cutting on September 29

** Botanical separations not made.

during the year indicated a more thrifty growth at the 3-inch cut than at one inch and would suggest that during the next few years the effects of height of cut may be more apparent.

The general observation from one season's results on the effect of removing the first crop in the spring suggests that a good stand of Ladino clover with orchard grass could be cut as late as an early head stage without adversely affecting the stand of clover, but where the Ladino clover is thin, an earlier cutting (as in the boot stage) will be more favorable for increasing the stand of clover. Cutting at the full bloom (or late head) stage in general increased the yield of grass but decreased the yield of clover in the first and subsequent cuttings, and particularly where nitrogen fertilizer had been applied.

The Effects of Nitrogen Fertilization, Irrigation and Clipping Treatments on the Yield and Botanical Composition of a *Poa pratensis*-*Trifolium repens* sod

Experiments were started this year to study the effects of time and rate of nitrogen fertilization, height and frequency of clipping, and irrigation on the total and season distribution of yield, the botanical composition, the nitrogen recovery, and the rhizome growth of a Kentucky bluegrass and white clover sod. The sod had previously received no nitrogen fertilizer and had been managed under a system which would allow for an adequate storage of carbohydrate reserves. Since only small amounts of clover were present, a mixture of several types of white clover and Ladino clover was seeded over the entire area early in the spring. Liberal amounts of lime, phosphate, and potash were applied.

The growing season was characterized by high rainfall in May and June followed by very dry weather in July and August. During August and the latter half of July, the Kentucky bluegrass and white clover on non-irrigated plots made no appreciable growth.

Under irrigation, bluegrass and clover made excellent growth throughout the season. The plots of this series that received frequent applications of nitrogen fertilizer produced on an average 40 pounds or more of dry matter per acre per day during June, July, August, and September. The total yields for the season ranged from 7,482 to 8,182 pounds per acre depending on the clipping treatment. The botanical composition of these nitrogen fertilized plots, however, varied widely depending upon the clipping treatment. Plots clipped to a height of two inches 12 times throughout the season consisted of almost pure Kentucky bluegrass whereas those clipped more closely (1/2 inch and 1 inch), particularly in the early spring, contained considerable amounts of clover.

On plots that received no nitrogen but were irrigated, the clover population was so high during July and August that the yields were almost as high as on plots that received 40 pounds per acre of nitrogen after each clipping. The high percentage stand of clover was maintained on these plots during September and October but the yields during these months were lower than on plots which received nitrogen. These and other results obtained in this study suggest that when soil moisture is adequate white clover is relatively better adapted to the high temperatures of July and August than is Kentucky bluegrass.

Spring applications of nitrogen fertilizer gave large increases in yields of dry matter (irrigation was not necessary in the spring). In the first cutting the increase from 80 pounds per acre of nitrogen was almost twice as great as that obtained from 40 pounds. Undoubtedly part of the increase in yield from high rates of nitrogen fertilizer was made at the expense of carbohydrates stored during the previous year. For this reason the yields and nitrogen responses obtained next year should be particularly interesting.

Soil Moisture in Relation to Pasture Management

Soil moisture as measured by the electrical conductivity of gypsum blocks, was determined throughout the season at depths of 4, 10, 20, and 30 inches on irrigated and non-irrigated plots of Kentucky bluegrass that received different nitrogen and clipping treatments (1943 Annual Report, page 54). During the latter part of the season, soil tensiometers were installed on a few of the plots and the results obtained with these instruments were compared with those obtained by the gypsum blocks.

Rainfall was unusually high in May and June and during most of this period no appreciable differences in conductivity of the gypsum blocks were obtained. July and August were dry and by early August the moisture content of the soil was below the wilting coefficient to a depth of more than 20 inches. At 30 inches the soil moisture content remained above the wilting coefficient throughout the season.

It was of interest to note that, at the beginning of the dry period, most of the blocks at the 20-inch depth showed no change in conductivity until after the soil moisture at the 10-inch depth was below the wilting coefficient. Any variation in this respect appeared to be due to differences in the soil profile rather than to fertilization or clipping treatment. The gypsum blocks, however, were not sensitive to changes in soil moisture at moisture contents approaching the field capacity. In fact, preliminary results obtained in a comparison with soil tensiometers indicated that little change in conductivity occurred in gypsum blocks between tensiometer readings of 0 and 400 centimeters of water.

The Response of Various Forage Grass and Legume Seedlings to Phosphate Fertilization under Greenhouse Conditions

The seedling response of four grasses and four legumes to six levels of phosphate fertilization was determined in the greenhouse on Hagerstown soil. The eight species under test were timothy, orchard grass, bromegrass, tall oat grass, alfalfa, Ladino clover, red clover, and birdsfoot trefoil. Yields of tops and in some instances of tops and roots were determined 9 to 12 weeks after seeding. In one trial the plant material was analyzed for total phosphorus content. Each of the four grasses showed greater increases in yields of dry matter and greater percentage increases in yield from high rates of phosphate fertilization than did any of the legumes. This differential response of seedlings of grasses and legumes to phosphate fertilizer was particularly apparent in alfalfa, red clover, orchard grass, timothy, and bromegrass. At the lower phosphate levels, alfalfa and red clover produced higher yields of dry matter than timothy, orchard grass, and bromegrass, but at the higher levels of phosphate fertilization the grasses yielded more than the legumes.

Results obtained with Ladino clover and timothy at different levels of lime, potash, nitrogen, and manure indicate that the differences in phosphate response of the grass and legume could not be attributed to a deficiency of nutrients other than phosphorus.

The results obtained in these studies have been submitted for publication (page 64).

Inhibitory Plant Growth Factors in Partially Sterilized Soils

Earlier studies showed that heavy phosphate fertilization corrected the inhibiting effect on plant growth that sometimes follows steam sterilization of soils (1943 Annual Report, page 55). Further studies have substantiated the earlier indications that the inhibiting effect of sterilization is not due to phosphate fixation. Additional studies are in progress to determine the cause of the injury.

Carbohydrate Metabolism of Grasses

Reserve studies similar to those carried out with ryegrass (1942 Annual Report, pages 51 and 52, and 1943 Annual Report, pages 52 and 53) were begun with orchard grass. A preliminary analysis of plants growing in soil in 1-gallon pots was made for the purpose of determining the distribution of carbohydrates in the

different plant parts. It may be seen from Table 7 that from the upper to the lower parts of the aboveground portions there is a decreasing gradient of sugars and an increasing one of fructosan. The large percentage of fructosan (23 to 36 per cent) in the stubble, which constitues a third of the dry weight of the whole plant, makes fructosan an important plant constituent. The steep gradients suggest the importance of height of cutting in experiments involving plant reserves. The roots are similar to the upper leaves in soluble carbohydrate content, though not in total alcohol soluble matter.

Table 7. Carbohydrate analyses of orchard grass plants.

Part of plant	Percentage of plant in each part	In per cent of dry weight: Dry matter soluble in alcohol	Reducing sugars	Sucrose	Fructosan
Upper 2/3 of leaves	14.0	33.2	1.4	8.4	7.6
Lower 1/3 of leaves	12.1	23.2	1.2	5.8	22.0
Upper 1/2 of stubble	9.4	16.7	1.9	3.6	23.7
Lower 1/2 of stubble	23.6	9.4	0.7	2.6	36.2
Roots	40.9	16.5	1.2	8.9	8.2

An experiment to measure carbohydrate changes in plants subjected to successive cuttings and to measure the effect of added nitrogen fertilizer on these changes was begun. The plants growing in pots were clipped to a height of two inches on January 4, 1944, and twice later, the clippings being 35 days apart. One series received no added nitrogen after the experiment was begun, another received nitrogen after each clipping. Plants were taken up for sampling 3, 7, 14, 21, 26 and 35 days after each clipping and were divided into tops (above the 2-inch level), stubble and roots which were preserved and extracted with alcohol for carbohydrate analysis. The dry weights only are now available and part of them are presented in Table 8. In spite of the successive cuttings, the stubble and roots have increased steadily in weight and the successive new top-growth yields have not decreased. Added nitrogen has increased the yield of tops and stubble but not of the roots.

Table 8. Dry-weight yield of parts of orchard grass plants subjected to successive cuttings (average of two replications of three pots each) in grams per pot.

Date		No nitrogen	Nitrogen added
Jan. 4, date of first cutting	Tops	2.41	2.68
	Stubble	2.87	3.18
	Roots	2.60	3.50
Feb. 8, date of second cutting, 35 days after first cutting	Tops	2.07	4.92
	Stubble	3.46	3.80
	Roots	3.86	3.54
Mar. 14, date of third cutting, 35 days after second cutting	Tops	2.22	6.32
	Stubble	4.14	5.24
	Roots	5.36	4.48
Apr. 17, 34 days after third cutting	Tops	2.41	6.02
	Stubble	5.08	5.99
	Roots	6.65	6.30

Another similar experiment was designed to measure the effect of adding nitrogen at various times in relation to cutting of the early hay stage of growth on the aftermath. Orchard grass plants growing in pots in the greenhouse were cut on February 2, 1944. Nitrogen was added as follows:

Series A, No nitrogen added.
Series B, Nitrogen added 14 days before cutting.
Series C, Nitrogen added 7 days before cutting.
Series D, Nitrogen added on day of cutting.
Series E, Nitrogen added 7 days after cutting.
Series F, Nitrogen added 14 days after cutting.

Samples of the tops, stubble and roots were taken for analysis on the following days, 14 and 7 days before cutting for hay, on the day of cutting, and 3, 7, 14, 21, 28, and 35 days after cutting. The dry weights have been obtained and those for the day of cutting and for the aftermath on the 35th day after cutting are presented in Table 9. The maximum yield at the time of cutting at the hay stage was in the B series which had received nitrogen at the earliest date. The maximum yield of tops and stubble in the aftermath was obtained in the D series which received nitrogen on the day of cutting for hay. The roots were greatest in the series receiving no nitrogen. Carbohydrate analyses are to be made.

Table 9. Dry weight of parts of orchard grass plants fertilized with nitrogen at various times in relation to time of cutting for hay in grams per pot (average of two replications of three pots each).

Series (See text)	Weights at time of cutting, Feb. 2			Weights of aftermath, 35 days after cutting, Mar. 8		
	Tops	Stubble	Roots	Tops	Stubble	Roots
A	5.77	3.07	2.20	.61	2.82	3.81
B	6.42	3.40	2.02	4.70	3.60	3.30
C	5.65	3.19	2.19	5.08	4.00	3.55
D	-	-	-	6.17	4.40	3.29
E	-	-	-	4.11	3.81	3.30
F	-	-	-	3.26	3.90	3.20

PATHOLOGY

Studies in Ustilago striaeformis from Poa pratensis

Physiology of Afterripening in Chlamydospores. As reported earlier (1943 Annual Report, pages 57 and 58) neither contaminating organisms nor presence of host tissue aided afterripening of smut chlamydospores. It was found, however, that smut spores separated from host tissues by treating them in a Waring Blendor germinated more readily and to a greater degree than similar untreated spores. It seemed possible that the treatment scarified the spores thus hastening germination.

Effect of Storage at Lower Temperatures on Subsequent Afterripening of Chlamydospores. When chlamydospores of Ustilago striaeformis were stored in a moist chamber at 5° C. for 60 days, an afterripening period of 10 to 20 days at 35° C. was necessary to secure maximum germination while chlamydospores maintained at 25° C. before they were transferred to an incubator at 35° C. required only 3 to 5 days to reach maximum germinability. This suggested that partial afterripening may occur among spores stored moist at 25° C.

Effect of Moisture on Afterripening Smut Chlamydospores. Fresh chlamydospores were separated from host tissue by treatment in a Waring Blendor. The spores were washed three times in a centrifuge and collected on filter paper. The treated spores, along with a control (not treated in the Waring Blendor), were placed at different moisture levels in an incubator at 35° C. Spores stored dry were placed inside Petri dishes containing dry sheets of filter paper. Spores incubated partially dry were placed inside small, dry, open dishes which in turn were placed inside a Petri dish moist chamber. This permitted the filter paper bits

containing the spores to remain dry while the spores themselves were maintained in a humid atmosphere. Chlamydospores incubated wet were placed inside small covered dishes containing wet filter paper and these dishes in turn were placed inside Petri dish moist chambers. In this manner, the spores on the filter paper bits were in direct contact with moisture and were insured against drying out at the high temperature. The dishes in each environment were examined daily and the water replenished when necessary. Germination tests were conducted at frequent intervals.

The results show that afterripening of smut chlamydospores occurred when the spores were maintained wet at 35° C. Some afterripening apparently occurred among spores stored under partially dry conditions since germinability had increased to 25 to 50 per cent after 31 days. Also, spores agitated five minutes in a Waring Blendor began to afterripen under partially moist conditions 10 to 15 days earlier than spores treated for shorter periods or not at all. Chlamydospores stored dry at 35° C. failed to afterripen regardless of treatment.

The results of investigations on afterripening chlamydospores of U. striaeformis from Poa pratensis were presented at the meetings of the American Phytopathological Society and a paper was submitted for publication (page 64).

Studies on Crown Rust (Puccinia coronata) of Festuca elatior

Selection for resistance to rust. During the past two years, more than 200 plants of Festuca elatior representing many collections have been tested in the field and greenhouse for resistance to crown rust (Puccinia coronata). In the 1943 Annual Report, page 62, it was reported that several of the selections tested showed resistance to rust. Since then, one collection of meadow fescue from Maine has proved to be highly resistant or immune from infection by races of rust occurring naturally at State College. Additional material from the vicinity of the original collection is being tested for rust reaction. To date, all seedlings derived from some individual heads have been immune to rust while others are susceptible or show segregation. Plants of several infection types have been secured and should prove valuable for isolating and identifying physiologic races of the rust. For the most part, the scheme of classification of infection types produced by physiologic races of Puccinia graminis tritici on differential varieties of Triticum spp. has been followed. The infection types found to date include all but mesothetic and the extremely susceptible type 4 infection. Most susceptible meadow fescue plants can be classified as type 3 or intermediate between types 3 and 4.

Effect of Temperature on Infection of Meadow Fescue by Crown Rust. Last year (1943 Annual Report, page 62) it was observed that a greenhouse temperature of 72 to 80° F. was most favorable for development of crown rust. This phase of work is being continued using plants of different infection types under controlled temperatures. Results to date indicate that 15° C. is approximately the minimum temperature for rust development while 30° C. is the maximum.

Studies on Seed Treatment of Forage Crops

Field Tests. In the spring of 1944, tests were again conducted to determine whether or not seedling stands of forage legumes could be improved by treating seeds with fungicides (1943 Annual Report, pages 59 to 61). In cooperation with the Plant Pathology Extension Service of The Pennsylvania State College and county agents, 26 tests were distributed in different counties of the state. In addition, tests were conducted in Rhode Island, New Jersey, Maine, Delaware and New York through generous cooperation by workers in those states. Similar tests were conducted by the Laboratory in the vicinity of State College.

Intermittent heavy rains washed out most of the plots at State College so that few accurate seedling counts could be made. On the basis of tests throughout the state and the region, no striking or consistent improvement in seedling stands of forage legumes was obtained.

Tests with treated seeds of red clover were conducted on a larger scale on farms of The Pennsylvania State College, State College, Pennsylvania. Sufficient seed was treated with Spergon and New Improved Ceresan to sow strips approximately 18 feet wide on nearly 16 acres of land. Untreated seeds were sown in similar strips as controls.

Visual inspections as well as random stand counts within each strip were conducted at intervals throughout the growing season. Neither of these methods disclosed any differences in strips planted with treated or untreated seeds.

Viability Tests on Seeds of Alfalfa, Red Clover, Ladino Clover, and Sudan Grass Treated with Different Fungicides. Periodic germination tests conducted on seeds of forage legumes treated with different fungicides and then stored under different conditions (1943 Annual Report, pages 61 and 62) showed that none of the forage legumes were injured by the fungicides tested even after 18 months' storage. In addition, treated seeds sown in soil inoculated with *Pythium* spp. were protected to a considerable extent from damping-off indicating that little or no deterioration of the fungicides occurred during the storage period. The germination of treated seed of Sudan grass did deteriorate during storage.

Virus-like Injury of *Trifolium repens*

Further efforts to transmit the virus-like condition either mechanically or by grafts were futile. Excellent transmission of known virus in plants of *Trifolium repens* occurred when leaves of peas or clover were inoculated by means of the carborundum technic. Consequently, it was concluded that the virus-like symptoms were caused by genetic factors rather than a virus.

Studies on *Stagonospora* Leaf Spot of *Dactylis glomerata*

Source of Inoculum. During each growing season the past several years, spaced plants in the orchard grass nursery have been severely attacked by a leaf spot disease (*Stagonospora subseriata* var. *maculata*). When cultures of the organism failed to sporulate and greenhouse inoculations were unsuccessful, another source of inoculum was sought. Investigation showed that spores within the pycnidia in infected leaves remained viable six months or longer. Diseased leaves were therefore collected from susceptible plants during the summer and stored dry at room temperature for use during the winter months. Inoculum was prepared by macerating the leaves in a Waring Blendor thus liberating the spores from the pycnidia. The resulting spore suspension was atomized on leaves of susceptible plants and produced excellent infection. At present, plants from more than 150 clones of orchard grass are undergoing inoculation tests under controlled conditions. From these tests, plants showing different infection types will be selected for further study.

Age of Plant in Relation to Sporulation of Stagonospora. Earlier greenhouse inoculation tests revealed that although excellent infection occurred on susceptible plants, the organism failed to provide mature pycnidia and spores. Experiments are under way to determine whether the stage of maturity of the host influences sporulation of the pathogen. Susceptible clones of orchard grass are being grown in the greenhouse under conditions to encourage heading. At periodic intervals, representatives of each clone are removed and atomized with a spore suspension of the organism. The lesions on leaves of each set of plants so inoculated are examined periodically for presence of pycnidia. From these tests it is hoped that the life cycle of the organism may eventually be completed under controlled conditions.

Studies on *Cercospora zebrina* Leaf Spot of Forage Legumes

Variability in Artificial Culture. The pathogen, *Cercospora zebrina* has been described as attacking a number of forage legumes. No work, however, seems to have been done to determine whether or not the strains of the organism from one host species

can infect another host species. As a preliminary effort, a total of 98 mono-conidial cultures were isolated from alsike clover, red clover, and Ladino clover. Of this number, 88 were grown in 125 ml. flasks containing potato-dextrose agar. The isolates tested were grouped into seven distinct cultural types.

Mono-conidial isolates from red clover were the most heterogeneous having representatives in all but one of the seven types. Cultures from alsike clover were classified in four of the seven groups. The majority of alsike isolates were distinctive because of the red to purple discoloration imparted to the culture medium. Mono-conidial isolates from Ladino clover were the least variable, all being grouped into one class with the exception of a single isolate. Isolates from all hosts were somewhat unstable and sectored freely. None of the isolates produced spores in any appreciable quantity.

Trifolium pratense Disease Nursery

In cooperation with the Division of Forage Crops and Diseases, the Pennsylvania Experiment Station and other State Experiment Stations, a red clover nursery was established to test improved selections and strains of red clover from other parts of the country for resistance to disease in Pennsylvania. Seed of 12 strains of red clover were replicated three times in plots 2 by 15 feet. Of the strains tested, eight were supplied by the Division of Forage Crops and Diseases while four were supplied by The Pennsylvania State College.

Disease Survey Trips

Several trips were made during the growing season. On one of these trips (May 1944 in company with L. J. Tyler of the Emergency Plant Disease Survey), old stands of alfalfa in Pennsylvania were examined for presence of bacterial wilt. Nearly all fields more than three years old showed evidence of wilt infection, some being severely damaged. Sclerotium rhizodes was collected on Agrostis alba for the second time in a different section of the state than where previously found (1942 Annual Report, page 55).

On a trip through parts of Massachusetts, Vermont, New Hampshire and Maine (in company with R. C. Cassell of the Emergency Plant Disease Survey), more than 50 disease organisms were identified on 19 different forage crop hosts. Urocystis agropyri was found attacking Phleum pratense for the first time and constitutes a new natural host for this smut. The same smut was found attacking Agrostis spp., only one previous report (Wisconsin) having been made.

SUMMARY

COOPERATIVE ACTIVITY

The collaborators did not meet during 1944 but they sponsored a regional seed conference. The conference was held February 2 and 3 in New York City for the purpose of discussing various phases of the critical situation with respect to forage seed supplies and to develop suggestions and plans relative to what might be done to ameliorate the difficulty. A 16-page mimeographed report of the conference was prepared and mailed to each person attending the meeting as well as to other interested persons.

COOPERATIVE PROJECTS

A total of 19 cooperative projects are now active. Brief progress reports on these projects may be found beginning on page 5. Seven of the projects are concerned with breeding, six with pasture renovation, three with pasture management, one with micro-climate and plant growth, one with the nutritive value of pasture plants, and finally one cooperative project is concerned with over-liming injury. Several promising new strains of orchard grass, Kentucky bluegrass and white clover are being increased for further testing and perhaps general distribution. Results from the renovation experiments indicate that effective and practical measures may be adopted to increase materially forage production on run-down pastures. Moreover, by proper management a satisfactory production may be had during July and August when at times there is likely to be insufficient palatable herbage on the bluegrass-white clover pastures.

RESEARCH AT THE LABORATORY

Cytogenetics and Breeding

Studies of the inheritance of male sterility in orchard grass and white clover were continued. In more than 650 selections of Ladino clover, the range in seed set under bag was similar to that found previously in white clover. Data obtained in further studies of incompatibility in autotetraploid white clover were not in agreement with the previously published hypothesis of action of the incompatibility alleles in this material.

Inbreeding for the establishment of selfed lines was continued in orchard grass (some lines in I_4), Sudan grass, white clover (some lines in I_4), and Ladino clover. Open-pollinated seed for use in testing combining ability of the clones was harvested from plots of selected clones of white clover grown in association with

Kentucky bluegrass and of selected clones of Ladino clover grown with orchard grass. From the space-planted nursery, 267 new selections of Ladino clover were taken for planting in a polycross plot.

Replicated plots of a new strain and four standard strains of white clover were seeded in association with Kentucky bluegrass. Also replicated plots of a new strain of Ladino clover were planted in association with orchard grass for comparison with commercial Ladino. Strain trials of Kentucky bluegrass were continued and the results were consistent in general with those obtained previously. Seed was harvested from 15 isolation plots of meadow fescue and four of bromegrass.

Studies of inheritance of rust resistance in timothy and white clover were continued. F_1 plants of crosses for testing allelism of young and adult plant characters in orchard grass were grown in the greenhouse. F_3 progenies of the Poa compressa x P. pratensis hybrid indicated that in the F_2 plants, reproduction was predominantly sexual despite the fact that both parents were apomictic. Crosses are being made for an analysis of the inheritance of various leaf markings in Ladino clover. F_2 and backcross seed are being produced for a study of the inheritance of size differences between Ladino and white clover. A virus-like abnormality among plants of white clover was shown to be due to genetic factors.

Studies of the origin of aneuploidy in orchard grass are in progress, using seed progenies of euploid plants ranging from low to high in meiotic irregularity. Most natural stands of Festuca elatior sampled in the Northeast have proved to consist of diploid plants but one stand of hexaploid plants (tall fescue) has been found. Meiotic behavior in plants of tall fescue and in F_1 of perennial ryegrass x tall fescue indicates considerable homology between chromosomes of different genomes of the hexaploid. Hybrids of diploid and hexaploid F. elatior have been obtained for use in further analysis of the origin of the hexaploid.

By treatment of germinating seeds with colchicine, chromosome doubling has been induced in diploid meadow fescue and in Dactylis aschersoniana, the diploid species from which orchard grass may have arisen by chromosome doubling. Comparative studies of meiotic behavior in pairs of diploid and autotetraploid clones of perennial ryegrass were completed. The bearing of these results upon interpretation of meiotic behavior in autopolyploids in general was suggested. The autotetraploid clones of perennial ryegrass were consistently less winterhardy than the related diploid.

Several improvements in cytological techniques, developed during the last few years, were summarized for publication.

Physiology and Composition

In the greenhouse during the winter months the vegetative responses of 13 species of grasses and legumes to increased daylength (11 to 17 hours) resulted in elongated vegetative parts. In most species, the increase in yield of dry matter was small in comparison with the degree of elongation. The root-top ratios decreased with increasing daylength except for orchard grass, Kentucky bluegrass, and Sudan grass which were not affected appreciably.

A number of individual plants of orchard grass, meadow fescue, and white clover were grown under two conditions of supplementary light: (1) 6 hours of Mazda light at the end of the normal 10-hour winter day to provide a 16-hour day, and (2) the normal winter day plus one hour of Mazda light at midnight. The results of these trials indicated that the number of plants flowering, the number of heads produced per plant and the time elapsed from the time the lights were turned on until flowering was almost identical for the two light treatments.

The effect of soil and air temperatures on the emergence and early seedling development of eight additional pasture grasses and legumes was studied in the environmental control chambers. The analyses of the data obtained in this trial have not yet been completed.

Orchard grass-Ladino clover and bromegrass-Ladino clover associations in the field, as affected by height, time and frequency of defoliation, and by spring applications of nitrogen fertilizer were studied. During the first harvest year, nitrogen increased the yield of the associated grass at the expense of the clover. Both with and without nitrogen, the yield of clover decreased progressively as the first cutting date approached the maturity of the grass. The yield of the grass increased as the cutting date was delayed. Height of cutting had little effect on yield in the first harvest year, but observations suggested that a more vigorous growth was obtained when the herbage was cut to three inches than when cut to one inch.

With irrigation and heavy nitrogen fertilization, Kentucky bluegrass and white clover produced an average of 40 pounds or more of dry matter per acre per day during June, July, August, and September. The total yields for the season ranged from 7,482 to 8,182 pounds per acre depending upon the clipping treatments. With certain clipping treatments considerable amounts of clover were maintained even where nitrogen fertilizer was applied at the rate of 40 pounds of nitrogen per acre after each clipping. All plots received a heavy application of phosphate, potash, and lime. Irrigation without nitrogen fertilization resulted in extremely high percentages of white clover during midsummer and fall, and in July and August the yields were almost as high as

on plots that received nitrogen after each clipping. Although the high clover populations were maintained throughout September and October the yields were considerably lower during these months than on plots that received nitrogen fertilizer.

Soil moisture on non-irrigated plots of Kentucky bluegrass, as measured by the electrical conductivity of gypsum blocks, was below the wilting coefficient to a depth of more than 20 inches during most of August. At 30 inches the moisture content remained above the wilting coefficient. Gypsum blocks in contrast with soil tensiometers were not sensitive to changes in soil moisture at moisture contents approaching the field capacity.

Greenhouse studies of the seedling response of four grasses and four legumes to six levels of phosphate fertilization showed that the grasses responded more to high rates of phosphate than did the legumes. At the lower phosphate levels alfalfa and red clover in particular produced higher yields of dry matter than did timothy, orchard grass, and bromegrass, but at the higher levels of phosphate fertilization the grasses yielded more than the legumes. Apparently these differences were not due to a deficiency of nutrients other than phosphate.

Although heavy phosphate fertilization corrects the inhibitory effect on plant growth that sometimes follows soil sterilization, the data indicate that the inhibiting effect of steam sterilization is not due to phosphate fixation.

The effects of application of nitrogen fertilizer to the utilization of carbohydrate reserves in orchard grass are being studied under two management systems. When the orchard grass was cut every 35 days, the addition of nitrogen at each time of cutting increased the yields of tops and stubble but not of roots. A greater yield of hay was obtained when nitrogen was applied 14 days before rather than 7 days before cutting. The greatest aftermath yield was obtained when nitrogen was applied on the day of cutting rather than on the 14th or 7th day before or on the 7th or 14th day after cutting. The chemical analyses are not completed.

Pathology

Partial afterripening of chlamydospores of *Ustilago striaeformis* from *Poa pratensis* occurred when the spores were stored moist for 60 days at 25° C. but afterripening did not occur when they were stored at 5° C. Best afterripening of spores occurred when they were incubated wet at 35° C. Partial afterripening occurred when spores were incubated at 35° C. in a saturated atmosphere but without the spores being in direct contact with water. No

afterripening occurred among spores incubated dry at 35° C. Spores agitated in a Waring Blendor for five minutes began to afterripen under partially moist conditions earlier than spores treated for shorter periods or not at all.

A collection of meadow fescue (Festuca elatior) highly resistant to crown rust (Puccinia coronata) has been subjected to inoculation tests in the greenhouse and field. Plants of several infection types ranging from immune to susceptible have been isolated and will be used for identifying races of crown rust attacking meadow fescue. Greenhouse tests have shown that crown rust can develop on meadow fescue within a temperature range of 15° to 30° C.

Field tests with fungicide-treated seeds of alfalfa, red clover, and Ladino clover were repeated but showed no great promise. Treatment with fungicides apparently did not lower germination of alfalfa, red clover, and Ladino seeds even after storage for 18 months. The germination of Sudan grass seed was injured severely by New Improved Ceresan.

Studies on the Stagonospora leaf spot of Dactylis glomerata showed that spores remained viable for at least 6 months in dried plant material stored at room temperature. Infected leaves collected in summer provided inoculum for greenhouse tests the following winter.

Mono-conidial cultures of Cercospora zebrina isolated from Trifolium hybridum, T. pratense and T. repens were grouped into seven distinct cultural types when grown on potato-dextrose agar.

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Atwood, Sanford S. The behavior of the self-compatibility factor and its relation to breeding methods in Trifolium repens.

Cassell, R. C., and Kreitlow, K. W. Diseases of forage crops in Northern New England.

Garber, R. J. Plant breeding in relation to human nutrition.

Garber, R. J., and Atwood, S. S. Natural crossing in Sudan grass.

Hill, Helen D., and Myers, W. M. A schedule including cold treatment to facilitate chromosome counts in certain forage grasses.

Kreitlow, K. W. Ustilago striaeformis. III. A further study of factors that influence afterripening of chlamydospores from Poa pratensis.

Myers, W. M. Meiosis in autotetraploid Lolium perenne L. in relation to chromosomal behavior in autopolyploids.

Robinson, R. R. The response of various forage grass and legume seedlings to phosphate fertilization under greenhouse conditions.

Sprague, V. G., and Myers, W. M. A comparative study of methods for determining yields of Kentucky bluegrass and white clover when grown in association.

Appendix

(The responsibility for compiling each state report was assumed by the collaborator of that state)

PROGRESS REPORTS OF STATE STATIONS

CONNECTICUT (STORRS) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments.

Leaders: B. A. Brown and R. I. Munsell

a. Response to Soil Treatments. Analyses of alfalfa from plots receiving up to 600 pounds of 60 per cent muriate of potash disked in before seeding in 1941 show that the heavy initial applications resulted in a very high concentration of potash in the first few crops, but marked decreases (nearly 50 per cent) in the fourth cutting; in a large reduction in the Ca content; and in a 50 per cent reduction in the Ca:K ratio in the first cutting after fertilization. In the third year (1944) the heavy, infrequent potash plots had the poorest stands among 21 treatments. These results indicate it would be preferable to add potash in smaller, more frequent applications to the potash deficient soils of this region.

In comparison with calcic limestone, dolomitic limestone decreased the K and Ca, but greatly increased the Mg in alfalfa. Both forms of limestone maintained better stands and increased yields above plots not limed since 1929 (pH 6.0).

c. Effects of Amount and Depth of Applying Limestone. In 1944, for the third successive year, alfalfa yielded more on plots with three tons of limestone in 1933 and none since, than where smaller amounts were applied in 1933 and 1941.

d. The Role of Minor Elements in Fertilizing Alfalfa. Table 10 gives the boron content of pure alfalfa from variously treated plots and also the prevalence of boron deficiency symptoms during a severe drought in September 1944.

From 1939 to 1944, ten cuttings of alfalfa, totaling about 24,000 pounds of dry matter per acre, have been taken from some twenty plots which received borax at 20 pounds in 1938 and none since. The average boron content of that dry matter was 38 p.p.m., and thus about 0.9 pound of boron, or about 40 per cent of that contained in the 20 pounds of borax, has been removed in the hay.

Table 10. Boron deficiency and boron content of alfalfa.

General treatments (K added annually)	Boron in dry matter, 1944 (p.p.m.) First cut	Boron in dry matter, 1944 (p.p.m.) Second cut	Boron deficiency Sept. 1944 (per cent)
Manure at 10 tons per year	22	19	21
PK	21	18	21
PK + (borax at 20 pounds in 1938)	34	28	4
PKL + (borax at 20 pounds in 1938)	34	26	5
PKL + (borax at 20 pounds in 1938 and 1941)	45	36	2

On a dairy farm with a 5-year record, one 20-pound application of borax has increased the average boron content of the alfalfa from 15 to 35 p.p.m. and during one dry summer, raised the second cutting yield by over 50 per cent. On another farm with very sandy soil (Hinckley), alfalfa, top-dressed with borax at 20 pounds in 1943, yielded in the first cutting of 1944, 15 per cent more dry matter containing three times as much boron as that without borax.

On some heavily limed plots (pH about 6.75), treated and seeded to alfalfa in August 1941, boron deficiency has been so prevalent where no borax was applied that the stands of alfalfa and the yields of dry matter, including volunteer grasses, were reduced in all cuttings since the first one of 1943. The average reduction in dry-matter yields for the last three cuttings was 12 per cent. Stands and yields have been practically the same where borax was added at 20 pounds as at 40 or 80 pounds. Throughout the three years, however, pure alfalfa on the 40-pound plots has contained 10 per cent more boron than from the 20-pound, and the 80-pound plots 10 per cent more than the 40-pound rate. Pure alfalfa from the no-borax plots contained only 53 per cent as much boron as alfalfa from plots with borax at 20 pounds. There have been practically no symptoms of boron deficiency on any of the plots receiving borax. Such results have not been obtained on adajcent, not recently limed plots.

Title: The Maintenance and Improvement of Pastures.

Leaders: B. A. Brown and R. I. Munsell.

a. The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing. As stated in the last report (1943 Annual Report, page 74), several of the seventeen 2-acre pastures which have been in this experiment since 1921

were seeded to Ladino clover in the spring of 1943. Tillage, before seeding, was employed on only one plot. Even on the tilled plot, only 4 per cent of the area was occupied by Ladino in September 1944. These poor results were probably due, in part, to very dry midsummer months in both 1943 and 1944. Kentucky bluegrass has almost entirely recovered from the severe disking and the future chances of obtaining a marked spread of Ladino clover do not appear bright.

In spite of the fact that most of the plots had been refertilized with PKL during the fall of 1942 and spring of 1943, the average production was the lowest in 1943 of any season since the start of the project. The production averaged only 64 per cent as much as in 1942 or in the 1932-1941 period. The only plot which had an increased production in 1943 over the 1932-1941 period was the one given a P treatment in 1943 for the first time in its history. (The 1944 results have not yet been calculated).

c. The Effects of Various Chemicals on the Soil, on the Botanical Composition of the Sward, and on the Stands and Growth of Kentucky Bluegrass and Rhode Island Bentgrass. No new data in 1944.

d. The Adaptability of Varieties and Species of Grasses and Clovers for Pastures.

1. Among twelve varieties and strains of alfalfa seeded on quadruplicated plots in August 1941, the All ("Buffalo") variety, developed in Kansas, has maintained the best stand. In September 1944, it had a 93 per cent stand, while Grimm had only 55 per cent. The chief reason for this marked difference in longevity appears to be the resistance of All to wilt, a disease which seems to be increasing in importance in Connecticut.

Alfalfa variety tests extending over a period of thirty years show that the Common variety has maintained nearly as good stands as Grimm for two years, after which the former has thinned much more rapidly than the latter. In the current tests, Nebraska Common had about the same stands as Grimm at the end of the third harvest season, while Dakota Common had a much better stand than either. Because of slow recovery after cutting and in consequence the rapid spread of grasses, Ladak does not appear suited for Connecticut. The susceptibility of Hardistan to leaf spot is the chief disadvantage of that variety under our conditions.

2. Management studies have been conducted for five years on two Ladino clover-grass seedings. In 1944, for the third consecutive year, the 6 to 2, 8 to 2, and 10 to 2 inch systems had more Ladino and larger yields of dry matter than the 6 to 4, 8 to 4, and 10 to 4 inch cuttings. The 5-year average increases in dry-matter yields for the three closer cuttings are 15 per cent where timothy was the seeded grass and 9 per cent for the orchard grass-Ladino mixture. In both seedings, the best stands of Ladino in 1944 were on the

10 to 2 inch plots. During the past season, as in most years, deferring the first cutting of the timothy-Ladino seeding to June 15 resulted in a much larger production of dry matter (over 30 per cent above the 10 to 2 inch system); deferring the first cutting of the orchard grass-Ladino mixture to June 1 has not increased yields much above either the 8 to 2 or 10 to 2 inch systems. The lowest and highest average yields of dry matter for five years are 2,982 (6 to 4 inches, timothy) and 4,698 (deferred first cutting to June 15, timothy) pounds. The 6 to 4 inch timothy also had the least Ladino in 1944.

Crops for Fall Pasture: in Connecticut, September and October are the most difficult months in which to supply sufficient pasture. Crops which will grow well during the cool, short days of early fall may become very important for a well-rounded pasture season. For this reason, two experiments were conducted in 1944. In the first, barley was seeded on August 2 at 1.5, 3.0, and 4.5 bushels per acre; fertilized with nitrogen at 40, 80, and 120 pounds per acre; and the first cutting made at three different stages. In the second test, oats and barley alone and in mixtures with each other and with rye were compared under the same methods of fertilizing and harvesting.

Results (August and the first half of September were very dry): (1) There was no response to more than 40 pounds of nitrogen. (2) The average acre yields of dry matter were: on September 19, 627 pounds; on September 29, 1,056 pounds; and on October 17, 1,979 pounds. (3) For all of the first cuttings, the 3-bushel seeding yielded slightly more than the 1.5 bushel rate and practically the same as 4.5 bushels. (4) The plots cut first on September 19 were cut again on November 9 and the total yield for both cuttings was slightly smaller than obtained from one cutting on September 29. (5) The heavier the seeding, the poorer the recovery and growth after the first cutting. (6) On October 26, oats and barley yielded slightly more than either alone, much more than two mixtures of barley and rye, and over twice as much as Italian ryegrass. (Note: The nitrogen contents of the barley cuttings in the first experiment are being determined but cannot be summarized at this time.)

f. Causes of Fluctuations in the Prevalence of White Clover. Although most of the many old plots were carried through 1944, nothing not mentioned in previous reports was learned about the wide seasonal fluctuations of white clover in grassland. It was notable, however, that white clovers did not become re-established during 1944 on areas from which drought practically eliminated them in 1943.

A pot experiment was conducted to learn the effects of adding extract to Ladino seeded on soil liberally fertilized with CaMgPKB. The extracts had no apparent effects during 1944.

DELAWARE AGRICULTURAL EXPERIMENT STATION

Title: Pasture Management and Milk Production.

Leaders: C. E. Phillips, T. A. Baker and A. E. Tomhave.

Drought was again severe and the cows were off pasture for five weeks in midsummer. Ladino clover continued to give excellent yields. The total yields of green grass per acre were as follows: Ladino clover 18,700 pounds, Korean lespedeza 11,100 pounds and white clover 8,400 pounds.

The cows on grass alone continued to compare quite favorably with the pasture-plus-grain and the barn-fed groups.

Title: The Adaptation and Use of Improved Strains of Grasses.

Leader: C. E. Phillips.

The nursery trials of strains of several species of grass were continued. Yields taken at the hay stage in general support the first year's observations.

At Newark the outstanding strains were as follows:

Kentucky bluegrass	-	K10, K6, Primo (7053)
Red fescue	-	Quebec (2579)
Orchard grass	-	Commercial best, Brage and O-3 good
Perennial ryegrass	-	F.C.22764, Jaersk (2743)
Timothy	-	Milton (7365), F.C.22766
Smooth bromegrass	-	B-10, B-1, B-12
Reed canary grass	-	Commercial better than 2756
Tall fescue	-	2659 not as good as Alta
Redtop	-	7163 not at all promising

At Georgetown only a few of the species tested seemed desirable for pasture and hay on sandy soils. The best strains of these species are given below:

Smooth bromegrass	-	B-12, 2683-8, 2683-1
Orchard grass	-	Commercial best, Brage and S-26 good
Reed canary grass	-	2756 slightly better than commercial
Tall fescue	-	2659 much better than Alta
Red fescue	-	Quebec (2579)

MAINE AGRICULTURAL EXPERIMENT STATION

Title: Grassland Studies.

Leader: C. H. Moran.

Milk yields per acre were obtained again this year from the series of fertility paddocks at Highmoor Farm. The results were comparable to those obtained in previous year but were somewhat lower because of the lack of moisture during critical periods. For a period of 40 days from April 27 to June 7, the total precipitation was 0.3 inch at Highmoor. Again in August the total rainfall for the first 24 days was only 0.02 inch. The 1944 seasonal rainfall is compared with the previous 9-year average below:

Month	1944	Average
May	.30	3.27
June	6.40	3.49
July	2.87	3.61
August	1.30	2.58
September	6.05	3.27
October	4.36	3.35

Ten acres of second crop Ladino clover were harvested for seed. The complete crop has not been threshed but preliminary threshings indicate high seed yields with a germination of 60 per cent not including hard seeds. A large quantity of seed was left behind because of the lack of equipment for harvesting short-stemmed seed heads.

A forced draft-ventilation hay drier was installed in the mow at Highmoor Farm. Studies will be made on the practicability of this type of drier for this area.

Determinations were made by Mr. Plummer of the carotene content of mixed grass-Ladino clover silages put up with and without phosphoric acid. In general, the carotene content of the silage preserved with phosphoric acid was slightly higher than that of silage made without a preservative. The carotene content varied from 50 to 70 p.p.m. There was a slight destruction of carotene with age. Additional data on carotene values will be obtained this winter on mixed grass-Ladino clover silage put up without a preservative.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

Title: A Study of the Responses of Different Hay and Pasture Seeding Mixtures to Nitrogen Fertilization.

Leader: W. G. Colby.

The details of this project are given in the 1943 Annual Report, pages 82 to 84.

Rate and Time of Application. As a result of last year's experience, the rate of nitrogen application was reduced from 450 pounds of sodium nitrate to the acre to 360 pounds. A change was also made in the method of application. Instead of applying all of the material early in the spring, half of it was applied in the spring and the other half during the first week in July. As a result, no lodging occurred in the hay plots and the amount of early spring growth in the pasture plots was not as heavy.

Dry-Matter Yields. Yield increases, as a result of nitrogen fertilization, were similar to those reported last year. Dividing the application reduced peak yields of herbage early in the spring and increased them during midsummer. This was particularly noticeable in the case of the hot-weather tolerant grasses such as orchard grass, smooth bromegrass and meadow fescue.

Most of the growth response from nitrogen fertilization with all grass species was accounted for in the first harvest following application of the material. In the pasture plots practically all of the increase in yield from the April-applied nitrogen was recorded in the May harvest and most of the increase in yield from July-applied nitrogen was recorded in the early August harvest.

The responses of different grasses to nitrogen fertilization were similar to those reported last year. The effect of nitrogen on the clover population was also similar.

Title: Strain Trials with Grasses.

Leader: W. G. Colby.

Winterhardiness of Orchard Grass Strains. Of the orchard grass strains tested thus far, most of those which possess the desirable characteristics of leafiness and late maturity have been subject to winter injury, particularly in newly established seedings. Established stands have been relatively resistant to winterkilling where soil fertility has been maintained and grazing controlled.

In order to determine the winterhardiness of six different orchard grass strains, three plantings were made at ten day intervals late in the summer of 1943. Observations on winter-killing were made on April 27, 1944.

Strain	Seeded Aug. 26 per cent stand Apr. 27	Seeded Sept. 5 per cent stand Apr. 27	Seeded Sept. 15 per cent stand Apr. 27
Hercules	50	20	5
S-37	5	0	0
S-143	2	0	0
Avon	95	60	35
Finnish Late Hay	40	10	5
Tammisto	40	10	5
Check (Commercial)	50	10	5

Avon orchard grass matured about the same time as the commercial check, Hercules about four days later and the other four strains about ten days to two weeks later. The Finnish strains (Finnish late hay and Tammisto) are the only ones thus far tested which combine lateness of maturity with a considerable degree of winterhardiness.

The winter of 1943-44 was a severe one from the standpoint of winter injury to vegetation and some strains of orchard grass suffered injury even in established stands. Strains in a 3-year-old row nursery of orchard grass strains showed the following results:

Strains showing no apparent injury: Commercial, Scandia II, Tammisto.

Strains showing noticeable injury: Brage, Tardus II, O.A.C. No. 1.

Strains showing severe injury: S-26, S-37, S-143, Akaroa, New Zealand.

Time of Planting Trials with Smooth Bromegrass. Successive summer seedings of smooth bromegrass (Canadian strain) and Ladino clover, both with and without a light seeding of oats, wheat, and rye, showed that early seedings were much better than late ones. Seedings made on August 19, 1942, resulted in an excellent stand of both the grass and clover by the summer of 1943. Seedings made on September 2 resulted in a fair stand of bromegrass but no Ladino clover. Later seedings resulted in no clover and very poor stands of bromegrass.

A light seeding of oats had an injurious effect on the August seeding but was of some benefit to later seedings. Late seedings with wheat and rye showed some benefit from the companion crop. These results indicate that summer seedings of smooth bromegrass should be made early--probably not later than is safe for the summer seeding of alfalfa or Ladino clover--without a companion crop of oats, wheat, or rye.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Title: Producing the Full Roughage Requirements on New Hampshire Dairy Farms.

Leaders: Ford S. Prince and Paul T. Blood.

The pasture phase of this project was especially emphasized in 1944. Eight outlying pastures seeded to one or more large grasses and Ladino clover were studied and six were harvested at intervals during the season. Two pastures had not been harvested in 1943 and two that were harvested in 1943 were omitted in 1944 because of changes in plans of the owners. Difficulties in management have been encountered due to the plots being too small to fence separately. The earlier maturing grasses were too far along when the cows were turned in at the normal time and these grasses became woody and had not been grazed properly. This has been particularly true with orchard grass. New seedings are being made in 1945, using each grass on an area large enough so that it can be fenced and managed as a separate unit.

Influence of Ladino Clover on Yields. One of the pastures was over-grazed in 1943 so that the Ladino was killed. In another pasture the Ladino winterkilled. Yields in pounds per acre, oven-dry weight, for 1943 and 1944 are listed below for these two pastures to show their relative yields:

	1943	1944	Difference
Angell pasture	6337	4405	1932
Drinkwater pasture	3457	1874	1583
Average	4897	3139	1758

A similar study of the other four pastures which were harvested during both seasons shows that they yielded 38 pounds more in 1944 than in 1943. There was a good percentage of Ladino in these four pastures in both years.

Seasonal Yields of the Grasses. Of the grasses under study, orchard grass is the first to reach the pasture stage. It is followed closely by smooth bromegrass, with the others coming along more or less together. In July, orchard grass, reed canary grass and smooth bromegrass are more productive than the others

while in the fall tall fescue appears to make the most growth. This is followed closely by reed canary grass. On wet land reed canary grass would probably exceed tall fescue in yield during autumn.

Palatability. We have tried to secure farmer opinion as to palatability in order to supplement our own judgment and observations. There is considerable difference of opinion among farmer cooperators, particularly in respect to orchard grass. Two men stated in the summer of 1944 that they would not seed orchard grass again, however, one of them revised his opinion by the close of the season. Another farmer who had nothing but orchard grass in comparison with a commercial mixture stated his cows ate it very well and believed it made enough more fall growth than the other seeding to be of significant benefit. One farmer believes that tall fescue has promise because of its high autumn yield, while another states he would not seed it again because of its unpalatability. All appear to agree that smooth bromegrass ranks high in palatability. Our own rating, ranking the grasses in descending order, is as follows: Smooth bromegrass, timothy, perennial ryegrass, reed canary grass, orchard grass and tall fescue. Palatability appears to be closely associated with softness of tissue.

Response to Nitrogen. Two of the pastures were again treated with different amounts of nitrogen in 1944. In one of these the Ladino had winterkilled, in the other there was a good stand of Ladino. Yields in pounds per acre, oven-dry weight, are shown below:

Ammonium nitrate, pounds per acre	Angell pasture, no Ladino	Peter's pasture, Ladino persisted
None	3569	5943
100	4692	5525
200	4455	6059
300	4905	

It will be noted that the grass responded to nitrogen in the Angell pasture where there was no clover but that there was no response to nitrogen in the Peters pasture. We have seen no detrimental effects to Ladino either in 1943 or 1944 in using nitrogen. Nor have we found any economy, so far, in using nitrogen on a pasture where there is a good stand of Ladino.

Competition with Ladino clover. Competition of each of these grasses with Ladino is being studied in those pastures where Ladino persists. Our estimates show reed canary grass to offer

most competition. This is followed by tall fescue and orchard grass in order. Smooth bromegrass, timothy, and perennial ryegrass follow in the order named but are very close together in this respect.

Rate of Seeding Trials. Two rates of seeding trials with orchard grass are in progress in each of two pastures. Yields in pounds per acre, oven-dry weight, are shown below:

Orchard grass seeded, pounds per acre	Lacoss pasture	Orchard grass seeded, pounds per acre	Slayton pasture (only two) harvests made)
3	4769	5	2191
6	5612	10	2809
9	5965		

These data show increasing yields for increasing amounts of seed. Stand counts in Lacoss pasture showed 10 per cent more orchard grass and 5 per cent less Ladino in the 9-pound than in the 3-pound seeding rate.

Comparative Yield of Simple Mixtures Using Large Grasses and Complex Mixture with a Variety of Grasses and Ladino Clover. In three pastures a complex commercial pasture mixture was seeded on part of the field in which our plots are located. Yields of these complex stands have been taken for comparison. The average of all large grasses in three pastures yielded 5,657 pounds in 1944 while the average yield of the complex mixtures was 5,289. The swards of the complex mixture show a fairly high content of redtop and Kentucky bluegrass.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Title: Belle Ellen Pasture Experiment.

Leaders: C. B. Bender and Claude Eby.

The Belle Ellen pasture area, comprising 45 acres divided into 11 pastures under rotation management, carried 42 head of milking Holsteins for 77 days and 46 head of milking Guernseys for 1935 days. Because of severe late summer drought these pastures produced per acre only 1,142 pounds of four per cent fat corrected milk.

Title: Fertility Levels on Dairy Farms.

Leaders: C. B. Bender, Firman E. Bear, and Claude Eby.

A complete description including method of procedure of this project is contained in the 1941 Annual Report, page 83. The pastures furnished 135 days of grazing for milking Guernseys and Hosteins.

The average dry-matter yield per acre of the 20 bluegrass-white clover plots was 3,208 pounds and the 20 Ladino clover-grass plots averaged 3,907 pounds per acre. Potash continues to be an important factor in Ladino production in these trials.

The plot receiving no potash yielded 1,574 pounds of dry-matter per acre.

The plot receiving 50 pounds of K_2O yielded 3,189 pounds per acre.

The plot receiving 100 pounds of K_2O yielded 4,010 pounds per acre.

The plot receiving 200 pounds of K_2O yielded 4,506 pounds per acre.

All plots receive an overall application of 250 pounds of 20 per cent superphosphate applied annually.

Where Ladino clover had been seeded on an old bluegrass sod in 1940 at the rate of one pound per acre, broadcast, without harrowing, the effect of manure in increasing the Ladino population was observed.

The plot receiving no manure, 23 per cent Ladino.

The plot receiving 2-1/2 tons of manure per acre, 27 per cent Ladino.

The plot receiving 5 tons of manure per acre, 47 per cent Ladino.

The plot receiving 10 tons of manure per acre, 34 per cent Ladino.

All plots receive an overall application of 250 pounds of 20 per cent superphosphate and 50 pounds of K_2O applied annually.

Title: Pasture Fertilization in Relation to Carrying Capacity (Wyker Farm).

Leaders: C. B. Bender and Claude Eby.

The Wyker Farm, comprising 51 acres grazed by growing dairy heifers, produced an average gain of 123 pounds live weight per animal at a cost of .026 cents per pound gain. The area yielded an average of 1,735 pounds of total digestible nutrients per acre, which is equivalent to 144 cow days for a 1000-pound animal.

Title: New Pasture Species.

Leaders: C. B. Bender and Claude Eby.

In a mixture of Ladino and Milton timothy seeded in 1940 on a 7-acre pasture, only 13 per cent of the timothy remained by the spring of 1944.

A 4-acre pasture seeded to Brage orchard grass and Ladino clover in 1943 looked very good, with 22 per cent of the mixture orchard grass and 44 per cent Ladino clover.

In a strip seeded to Alta fescue and Ladino clover, the cattle did not relish the fescue, but went to other grasses in the pasture.

Bromegrass and Ladino clover mixture for pasture furnished pasturage during the August drought, when bluegrass was dormant and could not be pastured.

Title: Beef Cattle Pasture Experiment with Orchard Grass.

Leaders: Gilbert H. Ahlgren and George Van Der Noot.

A description of this test is given in the 1943 Annual Report, page 86. Some changes have been made in the experiment as seemed desirable to put it on a better basis.

The application of 1,000 pounds of 5-10-5 fertilizer per acre was divided, an application of 600 pounds being made in early April and 400 pounds in early June. This was done because the 1,000 pounds of fertilizer applied at a single time imparted an apparent strong flavor to the grass and the cattle were reluctant to feed on it.

Paddock No. 1 was seeded with one pound per acre of Ladino clover; paddock No. 3 with 8 pounds of red clover; and paddock No. 4 with 10 pounds of alfalfa. This was done in late March without harrowing or working the soil but depending on alternate

freezing and thawing. A good stand of Ladino clover and red clover was secured by this method but the alfalfa was disappointing. The original stand of Ladino clover was lost in 1943 and this was attributed to the hot, dry weather and to overgrazing. Overgrazing was avoided by utilizing a temporary pasture when necessary.

Growth of the orchard grass was extremely rapid in the spring and in spite of heavy pasturing it was necessary to cut each paddock for hay during June. The yields of hay in tons per 4.5-acre paddock were as follows: paddock No. 1, 4.6; paddock No. 2, 4.0; paddock No. 3, 3.2; paddock No. 4, 5.5; and paddock No. 5, 5.5. The pasture yields as measured by clippings taken from cages were as follows: paddock No. 1, 2,030 pounds per acre; paddock No. 2, 3,470 pounds; paddock No. 3, 1,990 pounds; paddock No. 4, 1,974 pounds; and paddock No. 5, 1,874 pounds. Nineteen head of beef steers were kept on paddock No. 1 for 34 days, paddock No. 2 for 27 days, paddock No. 3 for 29 days, paddock No. 4 for 26 days; and paddock No. 5 for 20 days.

The beef animals weighed a total of 10,970 pounds when they started pasturing in the spring and they weighed 12,770 pounds when taken off in the fall. The total gain in weight thus was 1,800 pounds or equal to an average daily gain per animal of 0.627 pounds.

Title: Survey of Pasture Management Practices.

Leader: Herbert R. Cox.

This is a continuation of the study reported in the 1943 Annual Report, page 90 under the title "Survey of Multiple-purpose Sods". A preliminary report has been prepared entitled "How Certain New Jersey Dairymen Are Managing Their Pastures". This consists of a narrative statement of the practices followed by each of ten of the leading dairymen of the state. This study brings out clearly that the problem of pasture management is largely an individual one; the best plan for one man may not be the best for his neighbor. The most favorable plan for a certain farm must be determined by a number of conditions--the character of the land, the amount of land available for pasture, the rotation followed on the tillable land, and the desires, financial status and abilities of the farmer himself. Nearly half the farmers represented in this survey depend to a comparatively small degree upon permanent bluegrass pasture, and these are located largely on low, moist areas better suited to permanent grass than any other crop. Most of the pasture requirements of this group of dairymen are furnished by grass and legume sods in the regular farm rotation or temporarily out of the rotation as semi-permanent pastures or multiple-purpose sods. Alfalfa and Ladino clover are the leading legumes on these farms. Among

the grasses timothy is important, but there is increasing interest in such grasses as smooth bromegrass, orchard grass and reed canary grass. If the opinions of these men are representative of other forward-looking dairymen, we may expect in the future a strong tendency away from permanent bluegrass pastures for upland soils and a marked increase in semi-permanent sods, useful for hay and silage as well as pasture, the ingredients to depend upon soil and other conditions.

Title: Pasture Renovation Studies.

Leader: Herbert R. Cox.

The 1943 Annual Report, page 90, described six pasture renovation tests started in the spring of 1942 on poor pasture sods in north Jersey. The experimental area was limed and fertilized in early spring, then thoroughly disked to prepare a seedbed. A mixture of six different kinds of legume seeds was then sown, the mixture including birdsfoot trefoil, sweet clover, alsike clover, white clover, alfalfa and black medic, at the rate of 9 pounds per acre. A good stand was secured the first year in only one test, from fair to poor stands in the others. It was concluded that the rather unsatisfactory results were due to the weather being exceedingly dry in the spring of 1942 when the clover seedlings were becoming established. It appears probable that the success of this method depends to a considerable degree upon favorable soil moisture conditions at the time of seedling establishment.

During 1944 the clovers had largely disappeared from all of these fields, but the native grasses showed considerable stimulation, especially on the tests which had carried fair stands of clover in 1942 and 1943.

Title: Methods of Seeding Large Grass Seeds.

Leader: Gilbert H. Ahlgren.

Large seeded grasses such as bromegrass and tall oat grass are difficult to sow through ordinary seeding equipment. Seed of bromegrass was mixed with oats and with fertilizer on a farm scale test at Marlu Farms, West Long Branch, New Jersey. Alfalfa was sown uniformly over the entire field. For the bromegrass test the field was divided in half and about two acres sown by each of the above methods. The planting was made in August.

The bromegrass seed was mixed with one bushel of oats to every 12 pounds of seed and this amount applied on an acre basis. Again, 12 pounds of bromegrass seed was mixed with 250 pounds of 5-10-10 fertilizer mixture and this applied on an acre

basis. A disk drill set as shallow as possible was used in making the seeding. The alfalfa seed was sown through the grass seed hopper by extending the tubes in back of the disks. The entire field was cultipacked before and after seeding.

A visit in November showed the seed mixed with the fertilizer to have a definite advantage in growth vigor over that sown with the oats. The bushel seeding rate with the oats may be too high. The seed sown by mixing with fertilizer was judged to have an excellent stand, whereas that sown with oats was fair only.

Title: Drilling Lime, Fertilizer and Clover Seed into Poor Land.

Leader: Herbert R. Cox.

In the 1943 Annual Report, page 91, it was noted that clovers had been successfully established in early spring on small plots by opening a narrow slit in the sod with a grub hoe or a narrow garden hoe an inch or two deep, applying lime and mixed fertilizer in the slit, then scattering legume seeds on top the lime and fertilizer. Good stands have nearly always been secured in these seeded rows, especially on land so poor that there was little competition from established sod. Additional plots were seeded in 1944, again with favorable results, in spite of the long drought during midsummer. The leader is working with G.L.F. to develop a machine which will perform this operation on a field scale.

Title: Korean Lespedeza with Continuous Small Grain.

Leader: Herbert R. Cox.

The method of growing self-seeded crops of Korean lespedeza in continuous small grain has been under test in New Jersey for the past two years, oats being the grain used. Of the five farmers who started the project in the spring of 1943, three continued it in 1944 by seeding oats in the Korean sod without plowing. Satisfactory crops of oats were secured in 1944, together with excellent stands of self-seeded Korean lespedeza. Four new tests of this project were started in the spring of 1944 with seedings of oats and Korean. It appears probable that the plan will work about as satisfactorily in New Jersey as in the Midwest. To date the principal disadvantage of the system seems to be that oats grown continuously may become quite weedy. The weed factor can be largely eliminated, however, either by mowing the oats early for hay or silage, or by grazing the oats followed by clipping.

Title: Effect of Fertilizer Treatment and Stage of Harvest on Yield and Persistence of Timothy.

Leaders: H. C. Knoblauch and G. H. Ahlgren.

Timothy should be cut at the early heading or beginning bloom stage if high quality hay is to be secured. The effect of early cutting and of fertilizer treatment on production of timothy hay and survival of timothy plants has been studied over a period of four years.

The cutting treatments involve cutting at early heading, beginning bloom and late bloom. The fertilizer treatments consist of annual applications of the following on an acre basis: (1) control, (2) 400 pounds of 5-10-5, (3) 400 pounds of 5-10-5 plus 200 pounds of sodium nitrate in early April, (4) 1200 pounds of 5-10-5, and (5) 400 pounds of 5-10-5 plus 200 pounds of sodium nitrate applied at early heading. All plots were replicated three times.

Yields have been highest with treatment 4 followed by treatments 3, 5, 2, and 1 in that order. The late bloom stage gave the highest yield followed by beginning bloom and then early heading. Persistence has been best in plots cut at late bloom and in this respect the 1200 pounds of 5-10-5 fertilizer per acre was most effective. Serious thinning and loss of stand occurred in all timothy plots cut at early heading irrespective of the fertilizer treatment.

Title: Comparative Yield Test of 13 Grasses Under Two Cutting Treatments.

Leader: Gilbert H. Ahlgren.

This test was described in the 1943 Annual Report, page 87. The plots which were managed to simulate close grazing were not cut at 2-week intervals, as in 1943, but rather every time the grass got up to 3 to 4 inches. Those on the deferred basis were cut each time they reached 4 to 6 inches in height.

Yields ranged from 2,551 pounds of dry matter per acre produced by orchard grass under close cutting to 1,472 pounds for redtop under deferred cutting. Tall fescue, reed canary grass, bromegrass, and meadow foxtail were also comparatively good producers of pasturage. The plots cut most regularly produced slightly more dry matter than did those cut when at a 4- to 6-inch height.

Over 70 per cent of the total pasturage secured as measured by the dry weight of the clippings was secured before July 1. The rest of the season was extremely hot and dry at New Brunswick

and very little grass growth occurred from July 1 to September 15. Marked superiority of some grasses in resisting heat and drought and in making some growth as compared to others was noted.

Title: Comparison of Orchard Grass Strains and of Bromegrass Strains for Pasture Purposes.

Leaders: Gilbert H. Ahlgren, Carl B. Bender, and Carleton S. Garrison.

These tests are continuing but have been limited to observations only this past season. The Achenbach bromegrass continues to appear considerably more vigorous than does the commercial bromegrass. Contrary to last season's observations the strain 2683-1 now appears to be somewhat like Achenbach but slightly less vigorous.

The orchard grass strains S-26 and Brage have never completely recovered from the severe winterkilling of 1942-43 and commercial orchard grass looks much superior to either.

Six grass strains are growing on plots 1-1/3 acre in size. A similar test in Warren County is now established but only observational information is available.

Title: Improved Grass Species and Strains.

Leader: Gilbert H. Ahlgren.

Dry-matter production from 21 grass strains each replicated three times was collected this past year. These plots were harvested on a hay basis and data on vigor of aftermath secured by observation only.

Milton timothy compared with commercial timothy seed was about the same in performance. The average yield per acre for Milton was 2,568 pounds and for commercial 2,512 pounds. Neither strain produced any appreciable aftermath.

From a yield standpoint there was little difference among the orchard grass strains S-26, Brage, and commercial. The Brage and S-26 matured about four days later than the commercial.

Perhaps the most significant finding from these tests was the discovery of the large differences in performance between the bromegrass strains. The Achenbach strain produced twice as much dry matter as did a commercial seed lot and it was also

somewhat better than strain 2683-1. Strain differences will be strongly emphasized in New Jersey and the southern type of bromegrass recommended at least until further information becomes available.

The Weihen-Stephan Kentucky bluegrass was superior to commercial seed, producing about 10 per cent more dry matter. Reed canary grass, tall oat grass and tall fescue also performed well. Redtop, meadow foxtail, red fescue, Canadian wild rye and a number of others were less productive.

Tall oat grass was excellent in producing aftermath, growing back after being cut almost as fast as alfalfa. Orchard grass also produced a good aftermath, followed by bromegrass, reed canary grass, and tall fescue.

Title: Strain Studies with Zigzag Clover

Leaders: J. C. Anderson and G. H. Ahlgren

Seed was harvested from 30 promising zigzag clover plants and planted in flats in the greenhouse. Six of the strains germinated quite well and the seedlings were transferred to the field where they will be under observation in 1945.

A greenhouse test to determine optimum pH level for zigzag clover was conducted. The clones were grown at pH's 3.7, 4.7, 6.1, and 6.7. The total dry-matter yield at each level being 0.00, 39.0, 45.0, and 51.0 gms., respectively. Nodulation was well developed and well dispersed over the root system at pH's 6.1 and 6.7. At pH 4.7 nodulation was sparse and confined to the roots lying in the surface three-fourth inch of soil. Only plants at the two highest pH levels produced flowers and none of these set any seed. Plants grown at the two lowest pH levels showed high amounts of anthocyanin pigmentation on the lower levels. This was not present at pH's 6.1 and 6.7.

Title: Comparative Values of Various Grasses and Legumes for Poultry Range on Light Soils.

Leader: C. S. Garrison.

The tests comparing various grasses and legumes for poultry ranges on light soils were continued and are now in the third year. (See 1943 Annual Report, page 93.) Observations were made on the drought resistance and palatability of all the grasses and legumes included in each test.

Drought resistant differences in the grasses were very apparent. It so happened that on most of these tests there was little or no rainfall from late June until the final observations were made on August 1. The bromegrass showed the greatest drought tolerance. Orchard grass was good; meadow fescue, fair to good; and timothy and ryegrass, poor. The latter two plots were offering no grass for the pullets at the time the last observations were made.

The grasses most readily eaten by the pullets were orchard grass timothy, and ryegrass. The bromegrass was not grazed extensively until the other grasses were eaten off very closely. However, after the dry weather became severe and affected the growth of the other grasses the bromegrass was well grazed by the pullets. Mowing of the bromegrass and orchard grass when it reached a height of 8 inches helped to encourage grazing. The fescue was not eaten at all. Apparently it will not make a satisfactory constituent of poultry range mixtures.

Of the legumes Ladino clover, alsike clover and alfalfa were all well grazed. The red clover plot was not utilized even after the other legumes had been eaten down very closely. The Ladino clover was the first choice of the pullets, followed by alsike and alfalfa. The stand on the sainfoin plot was poor and it was impossible to get the desired data.

Title: Test of Grasses and Legumes for Poultry Ranges.

Leaders: Gilbert H. Ahlgren and Clarence S. Platt.

Some preliminary conclusions on the range test, described in the 1943 Annual Report, page 88, are available.

1. The combination of Kentucky bluegrass, Canada bluegrass, redtop, and red fescue in yard 1, with an overall seeding of wild white clover, proved to be the most efficient as a supplement to poultry rations used in three trials, particularly in the amount of mash required per unit of gain in body weight.

2. The combination of red clover, alfalfa, Ladino clover, and birdsfoot trefoil with an overall seeding of perennial ryegrass used in yard 4 proved to be the least efficient of the species tested. The pullets being reared on this mixture required almost 10 per cent more feed per unit of gain compared with those reared on the grasses used in yard 1.

Plans are being made for more accurate appraisal of Kentucky bluegrass vs. perennial ryegrass as used for poultry ranges. Attempts further to evaluate Ladino clover will also be made.

NEW YORK (CORNELL) AGRICULTURAL EXPERIMENT STATION

Title: The Improvement of Pasture and Forage Crops in Northern New York.

Leaders: D. S. Fink and R. Bradfield.

Significant responses from potash fertilization, over and above the usual manuring given to grassland, have been obtained during each of the past two seasons on several dairy farms. Further, at the close of the second season, Ladino clover was markedly more abundant on plots receiving additional potash.

Farmers in the area are showing considerable interest in pasturing oats. An additional 50 pounds of nitrogen an acre, over and above usual manuring, appears to about double the dry-matter yield of oats at the time of grazing. This additional nitrogen does not appear to interfere with the establishment of a good seeding catch.

Good seeding catches are being obtained when using Sudan grass as a companion crop. The rate of seeding Sudan grass is reduced to 20 pounds an acre. Again, additional nitrogen markedly increased the yield of Sudan grass at the time of grazing without interfering with the establishment of a good seeding catch.

On three of the cooperating farms, approximately double the use is being made of pasture as a source of feed for the herds as was formerly the case.

Several farmers were interested and given assistance in the production of Ladino clover seed. It seems likely that Ladino clover seed production will become a regular practice on many farms in the area in the immediate future. The procedure followed and results obtained by two of the farmers producing Ladino clover seed has been reported (page 110).

Title: The Value of Birdsfoot Trefoil as a Pasture Legume in New York.

Leader: H. A. MacDonald.

The work of this project continued during 1944. During the summer and fall period birdsfoot trefoil was less affected by drought and outyielded the white clover strains in the comparison. The grasses in association with birdsfoot trefoil were more productive during this period than in those plots affected to a greater extent by drought. This was due to moisture conditions

rather than to nitrogen. To date, the more dwarf forms of birdsfoot trefoil persist to a greater extent and are less injured than the taller-growing forms in pasture where continuous close grazing or clipping is practiced. The narrow leaf type has not been so persistent as the broad leaf type on seeded upland pastures although in some areas native stands do exceptionally well.

The selection and study of improved strains of birdsfoot trefoil for use as hay and pasture is being continued.

Title: The Influence of Grazing Management on the Yield, Botanical Composition, and Chemical Composition of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

This project as previously described was continued in 1944. In general, the yields of herbage produced in this trial have been declining with advancing years. Some weed encroachment is now evident. The highest yields of dry matter were produced, in 1944, from those treatments where a hay crop was taken followed by frequent clipping or grazing. The quality, as evidenced by maintenance of clover, in this wild white clover-Kentucky bluegrass sward, was superior where more frequent clipping was done. Where clippings were made at intervals of from one to four weeks, there was no difference in resulting herbage yield but an increase of legumes with the more frequent clipping. Clipping, of these species, to one-half inch markedly increased the yield over higher clipping heights regardless of the initial height or interval between clippings.

The clover has largely disappeared from the infrequently grazed plots and those clipped to a height of two or more inches, resulting in a weedy grass herbage of low quality. In contrast those plots which are frequently closely grazed or clipped maintain an amount of clover approaching 50 per cent of the total yield.

Title: The Study of Plant Associations for Pasture Purposes.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

The work of this project as described in the 1943 Annual Report, page 97, was continued in 1944. Due to prolonged drought conditions during the summer and fall and a severe infestation of white grub (Lachnosterna spp.) on the areas under study, the results obtained can be interpreted only in relation to these influences and not attributed wholly to the compatibility and production of the species associations under study.

In a trial of pasture mixture comparisons seeded in 1938 and 1940 there was little difference in dry-weight yield except where birdsfoot trefoil was added to the mixture. Under the conditions existing in 1944 the addition of this legume to the mixture increased the yield of herbage about 25 per cent.

Little difference was found between the yield of the various grass strains and species studied under the condition and management of these trials in 1944.

Title: The Influence of the Grazing Habit of Cattle on the Composition, Consumption and Utilization of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

This project was inactive in 1944. It is planned to continue this study in 1945.

Title: Pasture Survey of New York.

Leaders: D. B. Johnstone-Wallace and H. A. MacDonald.

Due to wartime conditions this project was inactive during 1944. This work is to be revised and continued when circumstances permit.

Title: White Grub Investigations.

Leaders: H. H. Schwardt and R. F. Pendleton.

Rotation studies in Steuben County, New York, show that potatoes following sod in a grub year may be injured as much as 60 per cent while potatoes following cultivated crops suffer less than one per cent of injury.

Extensive field tests with the new insecticide DDT (Dichloro diphenyl trichloroethane) indicate that at dosages up to 120 pounds an acre, it is not effective against white grubs.

"Milky" disease shows some additional promise of eventual usefulness in white grub control. Natural infections as high as 10 per cent have been found in one area in Clinton County. Laboratory studies on these grubs, made by the Bureau of Entomology's Japanese beetle laboratory at Moorestown, New Jersey, show that strains of "milky" disease specific for various species of Phyllophaga occur. At present "milky" disease can be cultured

only in the living body of the natural host. Until an artificial culture medium is found, there is little hope of producing sufficient spore material for widespread use against white grubs.

Title: European Chafer Investigations.

Leaders: H. H. Schwardt and C. Logothetis.

The European chafer, a recently introduced pest resembling our annual white grubs, now occupies an area of approximately 150 square miles centering about the village of Newark in southern Wayne County, New York. The annual spread of the infestation is small and is greatest toward the West. In 1944 several instances of severe injury to winter wheat were observed and this usually occurred when wheat followed oats or sod. Laboratory tests show that soil applications of DDT at the rate of 30 pounds to the acre are effective in controlling the adults, and first and second larval stages of this insect. Field tests in heavily infested wheat are in progress.

Title: Alfalfa Snout Beetle Investigations.

Leaders: C. E. Palm, H. H. Schwardt, and R. F. Pendleton.

Poison baits containing DDT were only moderately toxic to the alfalfa snout beetle and far less effective than standard baits in which sodium fluosilicate was the poisonous ingredient. Applications of DDT to growing alfalfa in both dust and spray form were also ineffective.

Title: Poultry Pastures.

Leaders: G. F. Heuser and L. C. Norris, Department of Poultry Husbandry, cooperating with D. B. Johnstone-Wallace and J. K. Wilson, Department of Agronomy.

On May 31, 1944, three lots of Single Comb White Leghorn pullets two months old were placed on pasture and grown for four months. The pasture consisted of Ladino clover and Kentucky bluegrass. The range was kept mowed so that green food was always available.

One lot received grain and a regular growing mash hopper-fed at all times. The second lot received the same feeds, but it was restricted by keeping the hoppers closed until just before noon. The third lot received only grain, both in the whole and ground forms, available at all times. The grain consisted of wheat. A mineral mixture was added to the ground wheat in order to make the mineral content comparable to that of the other rations.

There was little difference in the average weight between any of the lots at any time during the rearing period.

The birds having free choice of the regular ration ate more feed than the other lots. The difference after three months on pasture due to restriction of the regular ration was 1.1 pounds per bird, representing a 7.8 per cent saving in feed. After four months the difference was 1.27 pounds or 6.6 per cent. The feed consumption of the birds getting ground and whole wheat only was practically the same as that of the restricted lot. The birds getting the regular feeds consumed approximately the same proportions of grain and mash. The birds getting the wheat only consumed a much larger proportion in the ground form.

Since there were little differences in weight the restricted feeding resulted in somewhat better utilization of feed as shown by the pounds of feed required to produce a pound of gain.

The pullets having their ration restricted came into laying on range about a week later than the other two lots. There was little difference in production after the first two weeks between any of the lots. At six months of age there were fewer pullets in the restricted feeding group which were in laying condition. The average degree of sexual maturity of that lot at that time was less advanced than in the two free choice feeding groups, with no difference between the latter two. During the last month on range, when many of the pullets were laying, it is interesting to note that a greater number of the birds lost weight on the restricted feeding, 15.1 per cent of the individuals as compared with 8.1 per cent and 4.7 per cent of the birds in the free choice whole and ground wheat and free choice regular ration respectively.

At six months of age, 90 representative pullets from each lot were transferred to the laying house and fed a standard grain-mash laying ration. During the first four weeks in the laying house there was little difference in egg production. However, the pullets reared on free choice of the regular ration, gained more, ate less feed (3 per cent) and laid a larger egg during this month than the pullets reared on the restricted feeding plan.

Title: Breeding and Cytogenetic Investigations with the Forage Plants of New York.

Leaders: S. S. Atwood, R. G. Wiggans, and L. F. Randolph.

This project includes the work conducted in previous years under Bankhead-Jones Project No. 47, when the objective was mainly the improvement of red clover. Certain phases of the red clover work are being continued. The principal effort along this line in

1944 was the establishment of a repeat series of plots using the remnant seed of local strains, which had been collected by Doctor Wiggans and first sown in 1941.

As a first step in the breeding program for other forage crops, space-planted nurseries were started in 1944 of the following species: bromegrass, tall oat grass, timothy, alfalfa, and Ladino clover. Notes were taken in these nurseries throughout the summer, and preliminary selections were made among the outstanding plants. Certain of these individuals were brought into the greenhouse for the purpose of making preliminary determinations of self-fertility and for obtaining crosses between some of the plants. Another group of bromegrass plants were planted in replicated pots and placed in one of the controlled temperature rooms at the U. S. Plant, Soil, and Nutrition Laboratory, where an attempt is being made to develop techniques for detecting heritable differences within a species in ability to yield well at high temperature.

A new planting of several superior clones of zigzag clover also was started in 1944.

Selected clones of tetraploid red clover were increased vegetatively and tested for fertility under field conditions.

Title: Strain Testing and Breeding of Forage Plants for New York State and Vicinity, with Special Emphasis on Problems of Production During Periods of Midsummer Drought.

Leaders: S. S. Atwood and H. A. MacDonald.

Work on this project was initiated late in 1944, and there are no research results to be reported yet. An attempt is being made to collect seed of all improved strains and many distinct local ecotypes of several forage species, which may be able to produce greater growth during the summer season of normally low production. These seed lots will be sown in 1945 in plots where their yielding ability can be determined. Both agronomic and breeding phases of this problem will be considered, and the resulting materials will be utilized for selection and more refined breeding procedures.

Title: Breeding Alfalfa for Winterhardiness and Yield for Hay or Pasture.

Leader: S. S. Atwood.

The work previously conducted under this project demonstrated that several F_4 and F_5 lines from the hybrid Medicago sativa x M. falcata were outstanding in nursery row tests. A composite was

made of the open-pollinated seed from seven of these lines, but on account of Doctor Myers' health no seeding was made in 1944. It is planned to use this in 1945 for further testing and for multiplication of the seed.

Title: Breeding Timothy for Hay and Pasture.

Leaders: S. S. Atwood and W. I. Fisher.

The parental clones of strains No. 1777 and No. 4059 were increased vegetatively and planted in isolated plots on the University Farms in the fall of 1943. During 1944 the plots were cultivated at regular intervals, and panicles were removed to prevent shattering of seed. Since very few heads were produced in 1944, no attempt was made to save seed. It is planned to rogue the plots if necessary in 1945 and to harvest seed from the first crop. The two lots of seed which will be obtained in this way can be used as foundation stocks for the multiplication of these varieties.

PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION

Title: Preliminary Trials of Grasses and Legumes for Hay, Grass Silage, and Pasture for Dairy Cattle (see page 4).

Leaders: J. K. Thornton, S. I. Bechdel, P. D. Jones, P. S. Williams, H. W. Higbee, and A. L. Beam. (The U. S. Regional Pasture Research Laboratory is cooperating informally on this project.)

The objectives in this project are to obtain data, largely observational, on the establishment, persistence, productivity, and palatability of grasses and legumes for hay and pasture for dairy cows.

Additional information of an exploratory nature is being sought about the larger-growing and deeper-rooted grasses and legumes before more detailed experiments are established.

Experiment 1. To determine the suitability of meadow fescue and reed canary grass for pasture on wet land. Ladino clover was seeded with each grass.

Experiment 2. To evaluate Ladino clover from four seed sources and two types of birdsfoot trefoil, each in a mixture with orchard grass, under grazing by dairy cattle. Observational records are being obtained on productivity, persistence, palatability, and recovery following grazing.

Experiment 3. To evaluate grass-legume mixtures for establishment, persistence, palatability and productivity on a dry hillside.

Smooth bromegrass, tall oat grass, and crested wheat grasses were each used in combination with alfalfa and with Ladino clover. Plots 10 feet by 10 feet are replicated and are being grazed by dairy cattle.

Experiment 4. To evaluate grass-legume combinations under grazing with dairy cows. This pasture was seeded primarily for the production of pasture for the college dairy herd.

A 6-acre strip was divided longitudinally into three 2-acre strips and seeded to these combinations:

1. Orchard grass-alfalfa-Ladino clover.
2. Bromegrass-alfalfa-Ladino clover.
3. Bromegrass-orchard grass-alfalfa-Ladino clover.

Three narrow strips of Kentucky bluegrass were seeded across each of the 2-acre strips to test the effect of this species in combination with the others.

Title: The Importance of Soil Amendments in the Establishment, Maintenance, and Production of Grasses and Legumes (see page 4).

Leaders: H. W. Higbee and J. K. Thornton. (The U. S. Regional Pasture Research Laboratory is cooperating informally on this project.)

The object of this project is to determine the best lime and fertilizer rates and ratios for establishment, maintenance and productivity of grasses and legumes in different soil and climatic environments in Pennsylvania.

Experiment 1. Located on a well-drained soil derived from glacial ground moraine. The surface soil is a mellow light brown silt loam to a depth of 8 to 10 inches. The subsoil to a depth of 30 or more inches is a yellowish brown non-plastic silty clay loam. The fertility level is low and the acidity is high, pH 4.65. The soil has never received any lime or commercial fertilizer.

The lime applications per acre on each of the above species were as follows:

None, 1,000 pounds, 2,000 pounds, 4,000 pounds, 6,000 pounds, and 8,000 pounds.

Twenty per cent superphosphate was applied at the following rates per acre:

None, 250 pounds, 500 pounds, 750 pounds, and 1,500 pounds.

Sixty per cent muriate of potash was applied at the following rates per acre:

None, 83.3 pounds, 166.6 pounds, 250 pounds, and 500 pounds.

A uniform application of 30 pounds of ammonium sulphate was made over the entire area.

Four replicates of 22 lime-fertilizer treatments on five species or species combinations are included in this experiment. Each plot is 7 feet by 22 feet in size. Yields will be harvested as hay and aftermath in the summer of 1945. Data on establishment and persistence are being obtained and will be reported with the yields.

The following grasses and legumes were seeded in June 1944:

Birdsfoot trefoil, alfalfa, alfalfa-bromegrass, Ladino clover-orchard grass, Ladino clover.

Experiment 2. Plots similar to those in Experiment 1 have been started in the Appalachian Valley Ridge section of Huntingdon County. The soil mantle is thin and erosive and is underlaid by shale rock.

Title: The Adaptation of Species of Grasses and Legumes to the Varying Soil and Climatic Conditions in Pennsylvania (see page 4.).

Leaders: J. K. Thornton and H. W. Higbee. (The U. S. Regional Pasture Research Laboratory is cooperating informally on this project.)

The object of this project is to determine the adaptability of species of grasses and legumes to the varying soil and climatic conditions of Pennsylvania, as measured by establishment, persistence and productivity.

Experiments have been located on selected soil types in several physiographic regions of the state. At each site the following grasses and legumes will be evaluated singly or in combination with legumes:

Orchard grass, bromegrass, tall fescue, meadow fescue, tall oat grass, reed canary grass, redtop, timothy, meadow foxtail, Ladino clover, alfalfa, and birdsfoot trefoil.

Plots of each species or species combination are approximately 8 feet by 25 feet in size, and are replicated in a lattice arrangement. Lime and 3-12-6 fertilizer at 800 pounds per acre have been applied uniformly over each area. For yields, herbage will be cut with a small power mower.

Experiment 1. Located on a well-drained glaciated soil near Meadville in Crawford County. Prevailing vegetation was poverty grass. The soil had a pH of 4.65. The area had never received lime or fertilizer previous to the establishment of this experiment.

Experiment 2. Located on a deep, well-drained soil on the Allegheny Plateau in Clearfield County. The area had become impoverished by lack of lime and fertilizer.

Experiment 3. Located on poorly drained soil in the northwest glaciated region in Crawford County.

Experiment 4. Located on the Appalachian Valley ridges in Huntingdon County. Soil mantle very thin and erosive.

More experiments will be added to the above list for other areas of the state.

Title: Red Clover Seed Production.

Leaders: H. V. Higbee and J. K. Thornton.

Research as applied to the production of medium red clover seed during the years of 1943 and 1944 involved a study of the following factors as they may affect the commercial production of red clover seed in Pennsylvania. The factors are soils, time of cutting, height of cutting, the effect of hay left on when cut, boron, bees, and the different strains of medium red clover. Each of these factors is evaluated below.

1. Soils. The soil factor, as affected by type, fertility, and location, when evaluated gave differences in seed yields ranging from 10 pounds per acre on poor soils to 160 pounds per acre on good soils, with the average for all sites being 56 pounds of seed per acre which is approximately the same as the state average, 58 pounds of seed per acre.

2. Time of Cutting. To determine the best time to cut the first crop of medium red clover to permit maximum seed yields on the second crop six experimental sites were selected in the different clover seed producing areas of the state. At each site the clover was cut when in early bloom, half bloom

and full bloom. All experiments were in triplicate at each site. The data as collected from these experiments for 1943 and 1944 definitely show that for maximum seed production in Pennsylvania the first crop should be cut when maturity is about midway between half bloom and full bloom except for the high cool mountain areas of northern Pennsylvania and there, because of the short cool season, the highest yields of seed are obtained when the first crop of clover is cut in early bloom.

3. High vs. Low Cutting. Two cutting heights (2-1/2" and 8") were used to determine the effects of high vs. low cutting on clover seed yields. The data gave no advantages to high cutting even though clover seed producers in the potato growing areas were hopeful that high cutting would favor maximum seed production.

4. Hay Left On vs. Hay Taken Off. In the potato-growing areas the farmers prefer to leave the cut hay on the clover fields where it may decay and aid in the upbuilding of their soils for future potato production if it can be done without decreasing production of clover seed on the second crop. Data from several experiments (1943 and 1944) definitely show that where the first crop of hay is heavy it will reduce seed production on the second crop because of the effects of smothering, decay and possibly the carry-over of insects.

5. Boron. The importance of boron to legume seed production was tested on eight different soils. All experiments were in triplicate. The boron was applied at the rate of 20 pounds of borax per acre immediately after the first crop of hay was cut and removed. In four out of seven tests the boron treatments gave significant increases in seed yields. The increases varied from 39 to 70 per cent with the highest yields giving 284 pounds of seed per acre. The results obtained indicate that further research is necessary before boron deficient soils in Pennsylvania can be located and identified.

6. Clover Strains. A study was made of the seed-yielding capacities of approximately 30 different strains of medium red clover. The data showed that different strains of medium red clover have different seed-yielding capacities but there was only one outstanding seed producer. It was the "Penna. Scott" strain of medium red clover. This strain of medium red clover is a Pennsylvania strain. It is now under increase seed production on The Pennsylvania State College farms. Approximately 100 bushels of seed have been harvested and distributed to leading clover seed growers in Pennsylvania.

Title: The Importance of the Honeybee in the Pollination of Medium Red Clover.

Leaders: H. W. Higbee, J. K. Thornton, E. J. Anderson, and M. Wood.

To evaluate the importance of honeybees in the pollination of red clover, a series of experiments were conducted in cooperation with the Department of Entomology to determine if the honeybee could bring about the pollination of red clover. The data obtained show that the honeybee can and does bring about pollination of red clover. The data also show that in this region clover seed yields under high concentration of honeybees can be stepped up to five or six bushels of clover seed per acre in screen cages where all other insects are excluded. In open fields of clover on the college farms where honeybee populations were very heavy during 1943 red clover seed yields ranged from four to five bushels per acre.

For 1944 a farmer (Mr. Brion) in Tioga County, Pennsylvania, placed a number of hives of bees in his clover field when the second crop of clover came into blossom. A careful study of this clover field at harvest time showed that there was an average of 100 seeds per clover head in comparison with the normal seed set of from 20 to 35 seeds per head. The data are based on a total of 3,000 heads collected at random from the 30-acre field. All other experiments gave positive evidence that the honeybee can and does assist in the pollination of medium red clover, if the clover attracts the honeybee.

Title: Strain Tests of Red Clover.

Leaders: J. K. Thornton and H. W. Higbee.

Forty-nine strains of red clover were seeded in replicated plots at State College and 36 strains in plots located near Lancaster and near Meadville. Included in these trials are the better-known U. S. strains and many locally produced old-time Pennsylvania strains. Data will be obtained on adaptation, persistence and yields.

Title: Commercial Grass Seed Production.

Leaders: J. K. Thornton, C. O. Cromer and C. C. Wernham.

Interest in seed production continues in Pennsylvania. The acreage of creeping red fescue and chewings red fescue is holding about the same. There is an increasing interest in production of orchard grass seed and red clover seed. More

farmers are using orchard grass with Ladino clover for hay and pasture seedings. In many cases farmers plan to harvest seed from the first cutting and use the later growth for pasture.

Performance records were obtained for a second year from the cooperative U.S.D.A. uniform grass nursery. In general, seed yields were higher from row than from broadcast seedings.

Experiments in burning old growth of grass plus fertilization (30 pounds of nitrogen per acre) for control of disease and for increase of seed yields were continued. Yields in pounds of seed per acre for chewings fescue in 1944 were as follows:

	Not burned	December burning	March burning
Fertilized	162.1	88.1	132.7
Not fertilized	127.8	61.0	104.7
Difference	34.3	27.1	28.0

The above results were obtained on a 7-year old fescue plot which had been burned over two years ago. For two years previous to the burning, this plot produced no seed. There was a very low percentage of silver top disease in 1944. It was indicated that fall burning is more injurious than spring burning. We have observed during the past three years that burning the old growth in the spring, if done thoroughly enough to control silver top, will injure the new growth and reduce seed yields. When the silver top disease percentage is high, burning the old growth has resulted in higher seed yields. Application of 30 pounds of nitrogen per acre after burning markedly stimulated new growth and increased seed yields.

Brage orchard grass, burned and fertilized (30 pounds of nitrogen per acre) on April 1, 1944, produced the following results in pounds of seed per acre:

	Not burned	Burned	Increase due to burning
Fertilized	149	210	61
Not fertilized	113	165	52
Increase	36	45	

Increase in seed yield due to burning and fertilization of orchard grass amounted to 97 pounds per acre. It was noted that leaf spot was less severe on the burned plots than on the unburned plots. Records on percentage were not made, however.

An experiment in burning and fertilizing on old bluegrass pasture to ascertain the effects of these practices on yields of herbage, seed, and on the control of leaf spot and silver top gave some striking results. The old bluegrass was not grazed off in 1943, and weights taken in early April 1944 indicated a yield of three-fourths of a ton per acre. Fifty pounds of nitrogen per acre were applied on both the burned and the unburned areas on April 4, two days after burning off the dead growth. The results shown in Table 11 are based on one year's results and as such cannot be regarded as conclusive.

Table 11. Results of burning and fertilization on Kentucky bluegrass.

Treatment	Pounds per acre: Nitrogen	Pounds per acre: Green weight 2 cuts	Pounds per acre: Green weights per cent of check	Pounds per acre: Seed yields	Green stems per square foot	Per cent: Leaf spot*	Per cent: Silver top
Not burned	None	355.5	100.0	4.94	158	78.3	32.9
Burned	None	336.3	94.6	20.53	283	6.3	7.4
Not burned	50	468.9	131.9	2.12	188	80.8	66.8
Burned	50	1285.7	361.6	36.54	369	5.4	16.3

* Readings taken on second leaf below seed head by C. C. Wernham and J. K. Thornton, 5/29/43.

It was noted that:

1. Burning the accumulated dead grass in early spring greatly reduced the percentages of both leaf spot and silver top.

2. Seed yields were greatly increased by burning.

3. Nitrogen in addition to burning very materially increased the seed yields over that of the unfertilized burned area.

4. Burning alone did not increase the forage yields, but where nitrogen was applied after burning the forage yields were greatly stimulated.

5. Nitrogen without burning gave less than one-third the growth that the combination produced.

Title: Species, Varieties and Strains of Alfalfa.

Leaders: J. K. Thornton and H. V. Higbee.

Nineteen varieties and strains of alfalfa were seeded in replicated plots at State College, Lancaster and Meadville during the past year. Data will be obtained on adaptation, persistence and yield.

Title: Pasture Management Studies at Montrose, Pennsylvania.

Leaders: For the Pennsylvania Agricultural Experiment Station - C. F. Noll and S. I. Bechdel.
For the Division of Forage Crops and Diseases - M. A. Hein and S. R. Skaggs.

Management Studies on Permanent Pasture

	Net TDN (pounds per acre)
Pasture under controlled grazing	1048
Pasture continuously grazed	947
Pasture under controlled grazing (mowed for grass silage in 1943	1351
Pasture mowed for grass silage in 1944) 1358 grazing from aftermath) 418	1776

The above figures show that controlled grazing gives slightly more total digestible nutrients than continuous grazing. The pastures which are mowed and grazed on alternate years seem to be considerably more productive than those which are grazed every year.

Pastures in the Crop Rotation

	Net TDN (pounds per acre)
Fourth year of rotation - Cut for hay and aftermath grazed	
TDN from hay 1558	
TDN from grazing 1101	2659
Fifth year of rotation - grazed all season	2135
Fourth year - before July 15	1558
after July 15	913
Fifth year - before July 15	1213
after July 15	926

The afore-mentioned figures show that the rotation pastures are almost as productive after July 15 as the permanent pastures are during the spring months.

Grass-Legume Tests for Hay and Aftermath. Only six out of fourteen combinations yielded over 3,000 pounds dry hay per acre for the year. Five of these contained timothy and one contained orchard grass. The orchard grass was combined with birdsfoot trefoil and this is the first year in which the production from this plot has approached that of the other plots. Four of the plots contained Ladino clover and two contained alfalfa, the two legumes both appearing in one plot.

Stands

Legumes:

Alfalfa stands were only about 20 per cent.
Red and alsike clovers - only traces.
Ladino clover about 30 per cent to 40 per cent stands.
Birdsfoot trefoil 80 per cent or better.

Grasses:

All retained good stands except bromegrass and meadow fescue which were somewhat less than in former years.

The outstanding legumes this year were Ladino clover and birdsfoot trefoil. Timothy remained the outstanding grass in these tests.

Renovation Studies. These studies were discussed elsewhere in this report (page 21).

Uniform Nursery Grass Strain Tests. New seedings were made in 1944 for the continuation of this work. No data were taken from old plots.

Time of Application of Nitrogen Fertilizer. Fall applications on grass showed some benefit but maximum yields were obtained by applying the nitrogen at the beginning of the growing season in the spring.

Title: Silage Investigations.

Leaders: S. I. Bechdel, P. S. Williams, and S. R. Skaggs.

On account of shortage of labor and also because of shortage of crops for making legume silage, investigations were not very extensive in the summer of 1944.

The plan of using different preservatives that was carried out in 1943 (1943 Annual Report, page 103) was continued. Five small silos, with capacities of 5 to 8 tons, were filled with second-cutting alfalfa. The following treatments were used:

Silo No.	Per cent moisture at time of ensiling	Kind and amount of preservative per ton ensilage
4	52	200 pounds dry sorghum fodder
5	52	100 pounds dry sorghum fodder
6	40	Nothing
7	56	100 pounds corn and cob meal
8	58	200 pounds corn and cob meal

In addition to the above, one small silo was filled with second-cutting Ladino clover containing 70 per cent moisture with 200 pounds corn and cob meal as a preservative.

At this writing (February 1, 1945) these silos have not been opened. Unlike the work done last year, samples were not taken by borings through the silo walls and no fermentation studies were made. The experiment was planned this way in order to determine if the silage would be better preserved if not disturbed by sampling. It is planned to open all of the silos at an early date and examine for quality of silage.

One large silo, 10 feet in diameter, was filled with first-cutting Ladino clover with a moisture content of 72 per cent. In this silo, 200 pounds of oat feed per ton of green material were used. This silo has been opened and the silage has been found to be of excellent quality. A milk production feeding test is about to be started comparing it with corn silage.

A previous experiment completed in 1944, consisted of a feeding test comparing alfalfa corn meal silage with corn silage. Two hundred pounds of corn and cob meal per ton of green material were used as a preservative for alfalfa silage. The quality of this silage was very good and it excellend in palatability any legume silage ever produced at this station. Results of a short-time feeding trial indicate that it had a feeding value equal to corn silage of good quality.

A 7-acre field containing a good timothy sod, which was five years old, was divided into two parts. One part was top-dressed with 75 pounds of nitrogen per acre from ammonium nitrate while the other part was not treated. The grass from each field was harvested while in full bloom stage and stored in separate silos. Two hundred pounds of hominy feed per ton of green material were

used as a preservative. These two silages will be compared in a feeding test for milk production during the late winter months. The usual chemical tests on the silage will be made.

Another grass silage feeding test is planned for the late winter months. It has to do with orchard grass with and without nitrogen fertilization. Seventy-five pounds of nitrogen per acre were applied. The two resulting silages were stored in separate silos. About two hundred pounds of oat feed per ton of green material were used as a preservative.

It is of interest to report at this time that the yields of the nitrogen treated timothy and orchard grass fields were somewhat disappointing. The benefits of the nitrogen were more apparent than real. The yield data will be reported in connection with data on results of the feeding tests.

VERMONT AGRICULTURAL EXPERIMENT STATION

Title: Fertilizer Placement Studies for Legumes.

Leaders: A. R. Midgley and K. E. Varney.

The purpose of this work is to determine the relative value of applying manure, minerals and lime before vs. after plowing, on the growth and longevity of three legumes. Field plots, one acre in size, received 10 loads of manure, and to each load 100 pounds of an 0-20-20 fertilizer and 5 pounds of borax were added. The following seedings will be made across each acre receiving the two differently placed fertilizers: alfalfa-bromegrass, Ladino clover-timothy, and birdsfoot trefoil with timothy. The land was treated and plowed in the fall of 1944 and will be seeded the following spring.

Title: Comparative Longevity and Yield Tests with 10 Grasses and 4 Legumes.

Leaders: A. R. Midgley and D. E. Dunklee.

These trials are being conducted on heavy and light soil types. The land was seeded in the spring of 1943 on land that was fertilized and well prepared. The legumes were seeded across the grass plots, thus each legume was in combination with each of the grasses. Since the grasses are usually slow to become established, most of the forage produced during the first two years was from the legumes. Thus the type of legume grown had a greater effect on the yield than the grasses. Results show that the red clover plots produced the greatest yields followed by alfalfa, birdsfoot trefoil and Ladino clover. The Ladino

clover seemed to suffer badly from drought while the other taller-growing, deeper-rooted legumes grew well. Birdsfoot trefoil grew very well on the heavy clay land with a calcareous subsoil but poorly on the light soil. At present, it is difficult to determine which grasses are best, but after the second year they usually become predominant over the legumes and should show greater differences.

Borax in the fertilizer usually increases the longevity of Vermont alfalfa stands by at least a year. The possibility has been considered that borax might similarly increase the life of Ladino clover. Progress in this direction has been made. Boron deficiency "bronzing" of Ladino has been obtained and corrected with borax. The bronzing of the tips and edges of the leaflets is a good character for the recognition of boron deficiency.

Title: Cytogenetics and Breeding Investigations with Forage Legumes.

Leader: A. Gershoy.

1. Trifolium medium.

A. Factors affecting seed set. Twenty clones, D.1-D.20, representing diversisites in vegetative yield, habit of growth, and morphological characters were planted in replicated field plots for diallel crossing. A provisional technic has been adopted making use of low, wire cages and washed bumble bees. Only 45 of a projected total of 190 crosses were completed. The variation in time of blooming, scarcity of blossoms at a given time, lack of an abundant supply of bees and especially the lessened activity of caged bees prevented the completion of the experiment in 1944. An accessory series of reciprocal cross-pollinations between 10 additional clones, not immediately related to the D series, was completed.

The lush strain D.1, used in a completed diallel cross-pollination series, produced, uniformly, a very low average seed set when used as a female but in the majority of cases functioned moderately well as a male. This strain has consistently set very few or no seeds in open-pollinations. Abortive sterility in the female seems indicated and is being studied cytologically.

On the whole, cross-pollinations between strains not immediately related by origin from a common mother, and including U.S.D.A. clones, have yielded, almost uniformly, a significantly higher average seed set than crosses

between sister seedlings derived from the same mother by open-pollination, and also than backcrosses between these seedlings and the mother; however, a low number of outstanding exceptions to this general behavior were noted. In individual reciprocal pollinations comprising the three categories listed immediately above, some reciprocal pollinations yielded approximately similar while others gave decided unlike, average seed set.

Until the series of diallel cross-pollinations is completed a valid evaluation of the data cannot be made. However, if the technic of washing bees is trustworthy, it appears that cross-incompatibilities in the high polyploid, self-incompatible T. medium, are based on complex relationships (Atwood, S. S., Proc. Nat'l Acad. Sci. 1944). This supposition will be tested. At present it appears not improbable that cross-compatibility rather than cross-incompatibility may be expected in any cross-pollination made at random.

The seed set under cages averaged decidedly lower than that observed in open-pollinated heads of the twenty clones of the D. series. The seed counts for open-pollinated heads were taken from plantings adjacent to the cages. Significant exceptions were noted in some individual cages where the seed counts were high.

Bumble bee activity was not only erratic in cages but also decidedly curtailed even with supplemental feeding provided by the spraying of flower heads with dilute syrups. The bees apparently respond unfavorably to the lower threshold stimuli of light and, perhaps, warmth under cages in the periods of early morning and late afternoon, as contrasted with their high activity, at these times, on flower heads of uncaged clones in the same experimental plot. Although bee mortality was high throughout the period of study, the limiting factor seemed to be unwillingness of the bees to work the blossoms either steadily or consistenly.

Seed counts made in selected groups of ten open-pollinated heads indicate that average seed yields in the dry summer of 1944 equalled or surpassed those recorded in the wet summer of 1943. These records were taken on the D. clones and, also, on other desirable clones. In 1944 average seed set per head as high as 83.8 per cent and seed set on individual heads as high as 95.4 per cent have been recorded. The supposition made in 1943, namely, that the expected seed set in the field will be high with frequent bumble bee visits and interplantings of numerous clones, has been substantiated. The selection of desirable clones for further selection and breeding is not seriously limited by low seed set.

B. Vegetative yield. On soil sites low in water and in regions where rainfall is scanty in July and August, the slow recovery of zigzag clover after cutting in late June or Early July results in practically no aftermath for grazing or second cut. To ensure a second cut or adequate growth for grazing in the dry periods of summer it appears necessary to make the first cut very early in June, in the period of early flowering. Individual plants vary markedly in regenerative capacity, lushness, leafiness, woodiness of stem and apparent resistance to fungus infection.

2. Trifolium repens.

Tentative, field selections, based on vigor, size of parts, and aggressiveness, have been made in progeny rows of four seed sources of Ladino clover. In two of these seed sources a large number of "off" types were found.

3. Lotus corniculatus.

Some vigorous individuals of a high-yielding imported broadleaf strain have been selected for further study.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilization Studies.

Leaders: G. G. Pohlman and R. M. Smith.

Results from the three areas in which rate and frequency of application of superphosphate are being studied showed highest yields in 1944 for

400 pound application applied every 2 years at Milton,
200 pound application applied every 4 years at Lewisburg, and
400 pound application applied every 4 years at Wardensville

applied in the spring. Plots with spring application of phosphate following fall lime application have given consistently higher yields at all three locations than plots to which both lime and phosphate were applied in the fall. All yields were relatively low in 1944 because of dry weather. Legumes decreased during the season at all locations because of dry weather.

Chemical studies of the herbage show an increased phosphate content of the herbage from practically all of the fertilized plots.

However, the amount of phosphate removed in the herbage represents only a small part of that applied. The recovery is as follows for the 200, 400, 800, and 1200 pound applications.

Application (pounds)	Per cent of applied phosphate recovered in herbage		
	Milton	Lewisburg	Wardensville
200	19.8	17.1	3.2
400	21.1	22.1	3.0
800	24.1	19.1	3.4
1200	19.6	15.9	2.7

These figures reflect both yield and phosphate content of the herbage. The differences are rather small but do seem to indicate slightly less recovery at the 200 and 1200 pound rates of application. The low recovery at Wardensville is associated with low yields and little response to treatment. In all cases phosphate fertilizer increased the phosphorus content of the herbage.

Title: Revegetation of Hill-land Pastures in West Virginia.

Leaders: R. M. Smith, D. R. Browning and G. G. Pohlman.

1. Results Obtained from Tillage and Reseeding Trials Established Prior to 1944. Clipping yields (3 to 5 cuttings) were obtained from 14 pasture areas.

Detailed estimates of ground cover and of species composition were made at all locations.

On two areas at Morgantown, which represent the only results for the third season (including the seeding year), there was little difference among the yields on plowed, disked and surface treated, all yields being from about 1500 to 2000 pounds of dry matter per acre. Fall estimates suggest a small difference in quality favoring the plowed and shallow-tilled areas over the surface treated, but the main desirable species on all areas are Kentucky bluegrass, orchard grass, and white clover.

All other locations represent first year or second year results, and all were favorable to shallow tillage both in yield and in desirable species compared to surface treated, except at Morgantown, where the yields were identical although the species composition was superior on the shallow tilled. Second year results showed an average yield of 2300 pounds per acre for shallow tillage compared to 1350 pounds for surface treated.

The results from plowing were best of all in several cases, but were inferior in other cases. They were less successful than shallow-tilled areas in cases where dry weather followed seeding, and were damaged more by overgrazing. Erosion was noticeable on most plowed areas but seemed insignificant following shallow tillage.

Dry weather reduced the pasture yields during the summer and fall, but two shallow-tilled strips (Wetzel No. 2 and Greenbrier No. 3) produced more than 2 tons per acre of high-quality forage. The average dry-matter yields for the second season were approximately 2,000 pounds per acre for shallow tillage compared to 1,100 pounds for surface treatment alone.

Protein analyses of first year forage showed an increase of from one per cent to 10 per cent of protein in seven trials, from tillage and reseeding compared to surface treatment alone. Two comparisons of second year forage showed a continued advantage.

2. Tillage and Reseeding Trials Established in 1944.

Eighteen trials were established in 1944 involving a comparison of shallow tillage and reseeding with surface treatment and with untreated pasture. Plowing was not included, except at Morgantown because the results from plowing seemed less favorable than shallow tillage when grazing was not controlled.

Yields were taken from only four of these trials (Hancock County) and three of them were higher on shallow-tilled areas. The quality was much improved in all four cases. The average yield was 2,075 pounds on the tilled compared to 1,750 pounds on the surface treated.

The other trials were evaluated only by vegetation estimates and by observation. These indicated that the shallow tilled were generally superior to the surface treated. Several partial failures seemed to be due to insufficient treatment, inadequate tillage, or too late seeding.

General Conclusion.

Shallow tillage and seeding along with treatment seem to offer a means of quickly improving poor pastures, both with and without controlled grazing. The advantage over surface treatment is greatest when existing vegetation is of very poor quality but the soil has considerable depth and is potentially productive. If successful results are to be obtained, it is essential that the soil be well limed and fertilized, that the seedbed be prepared properly, that the proper seed mixture be used, and that the seeding be made early. Some of the earlier trials being studied are definitely inferior to later trials because of improvements in technique and treatment that are now being used.

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